THE BACK AND ITS DISK SYNDROMES

INCLUDING INJURIES, DISEASES, DEFORMITIES AND DISABILITIES

WITH NOTES ON

The Pelvis and Coccyx

BY

PHILIP LEWIN, M.D., F.A.C.S., F.I.C.S.

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ILLUSTRATED WITH 571 FIGURES AND 4 COLOR PLATES

Line Drawings by Harold Laufman, M.D.

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19[illegible]

Dedicated to

DOCTOR EDWIN W. RYERSON

My First Attending Orthopaedic [illegible]

and

DOCTOR JOEL E. GOLDTHWAIT

The man who made the [illegible]
[illegible]

To the Memory of [illegible]

DOCTOR JOHN L. PORTER

Who gave me the basic training [illegible]
of [illegible]
treatment [illegible]

To the Memories of Doctors:

HUGH OWEN THOMAS

JOHN RIDLON	**SIR ROBERT JONES**
RUSSELL A. HIBBS	**WILLIS C. CAMPBELL**
VITTORIO PUTTI	**GEORG SCHMORL**
E. G. BRACKETT	**ROBERT W. LOVETT**

FRED H. ALBEE

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FOREWORD

By Joel E. Goldthwait, M.D.*

In any discussion of the subject of backache the first consideration should be the structure of the spine itself. A study of comparative anatomy shows that the number of vertebrae in the lumbar region varies considerably from the many lumbar vertebrae in certain orders to the few in others, and that these differences occur at the thoracolumbar or the lumbosacral levels. Variations in the shape of the bones as well as in the number of the vertebrae in the lumbar region should be expected in the human spine. These anatomical peculiarities are only part of the problem. In considering the elements which make them a special source of difficulty, probably the most common is imperfect use of the body so that the weight bearing points in the lower back become abnormal.

Once the anatomy is understood there should be insistence on improvement of the mechanics of the region so that the best possible function may be expected. It should always be remembered that if it becomes necessary for one joint to be fused some other joint is obliged to take up the work which that joint formerly performed, and it should be appreciated that the joint which has the added strain put upon it may often cause as much difficulty as was previously present.

The chief point, with reference to surgery of the spine or to fusions of the joints, is to be perfectly sure that the lumbar spine is flat or that the joints are in the position midway between full extension and full flexion.

A feature which has received general recognition only recently was described by me a good many years ago—the backward displacement of the intervertebral disk or the nucleus pulposus. It should be recognized that when the nucleus pulposus is forced backward the lumbar spine, especially at the lumbosacral joint and the joint above, has been used with the bones in the position of extreme extension. This narrows the space between the vertebrae posteriorly, the nucleus pulposus is squeezed with the result that it breaks through the posterior portion of the controlling ligament. This ligament which holds the nucleus pulposus in its proper shape is much thinner in the posterior part of the spinal canal than around the sides and anteriorly. This naturally means that if the nucleus pulposus is compressed the weakest place for it to be forced through will be posteriorly.

Even though a laminectomy is performed it does not necessarily relieve the pressure at the sides of the extruded portion of the intervertebral disk. For this reason the lumbar spine should be flattened so that there is the least abnormal compression upon the intervertebral disk tending to crowd the nucleus pulposus out of place.

* Reprinted from the J. Bone and Joint Surg. 19 No. 3 July 1937 with slight editorial changes by Dr. Lewin with permission of the author.

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The subject of acute back strains or injuries, including industrial accidents and compensation features, has been presented in a way that should cause us all to appreciate the importance of this phase of our work. The most important thing to realize is that most of these cases represent a joint sprain and that the lumbosacral and the sacro-iliac joints are most commonly affected. Because of the structure of these joints, it is extremely difficult to protect or to immobilize them while the patient is ambulatory. The result is, that either comparatively little attention is given in the early stages, or treatment consists merely of strapping the back or administering drugs. The congestion of the part incidental to the sprain is continued, and instead of an acute sprain, in a comparatively short time a chronic condition results.

Since it is almost impossible to use any form of support that will satisfactorily protect these joints when patients are ambulatory, it is best to put these patients to bed for a week or ten days, with local applications to the low back in order to stimulate the circulation. This management affords the expectation of a rapid recovery and early return to work. With such handling, most of these cases become simple, they present no difficult problem or call forth reproach, as they certainly do at the present time in the minds of Compensation Boards.

Operations many times relieve pain but unless performed with full appreciation of the anatomical structure and the mechanics of the back the end-results are disappointing. On the other hand if all the features which have been presented are considered, probably fewer patients will be operated upon and the treatment of these cases as a whole will represent a greater credit to our profession than they do at the present time.

BOSTON, MASS.

PREFACE TO SECOND EDITION

This book was written for physicians and surgeons interested in the causes, diagnosis, prevention, treatment and prognosis of disorders involving the Back and its Related Structures. I have correlated and integrated facts, evaluated the theories and crystallized the concepts and misconceptions of diagnosis and treatment.

My aim is to place foremost the point of view of the patient in relation to discomfort, deformity and disability.

It would require several volumes to present all the material in detail. Therefore recommended reading is indicated all through the book.

Patients with back disorders are interested in three questions: (1) What is wrong? (2) What can be done about it? (3) What is the outlook? This book presents the facts needed to make a diagnosis and carry out the treatment of abnormal conditions that affect the human back and its related structures.

Throughout the book I have shown what should be done for a person with back trouble. I have outlined the operative technic step by step, so that the surgeon who is familiar with the anatomy and pathologic changes may perform many of the operations with precision and dispatch. The normal anatomy and physiology of the back are becoming increasingly important owing to industrial, athletic, military, and civil injuries and the insistence upon exact knowledge by industrial commissions, insurance companies and the courts.

Thirty-five years' experience as abstract editor in Orthopedic Surgery for The International Abstracts of Surgery, Gynecology and Obstetrics has brought to my desk many thousands of orthopedic articles, a large proportion of which were in foreign languages. In reviewing every article and in editing every abstract, I have been able to incorporate the cream of foreign orthopedic literature on Back Disorders from 1915 to 1953.

This book includes the important neurologic, neuropsychiatric, neurosurgical and roentgenologic contacts of the orthopedic surgeon during his daily routine practice, and it presents the important features of these specialties that are related to back disorders and the disk syndromes.

In no group of disorders confronting the orthopedic or industrial surgeon are the problems of diagnosis and treatment more important than in low back conditions.

There have been interesting and conflicting viewpoints. It is confusing and disconcerting to the physician who is called upon to make decisions regarding disk cases to read some of the divergent opinions of the "experts" regarding such subjects as myelography, treatment and spine fusion.

The "organic" vs the "psychosomatic" points of view regarding etiology and treatment may be in direct opposition. The danger is considerable

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in the psychosomatic approach which often overlooks serious organic trouble

I wish to offer my grateful tribute to such pioneers as Goldthwait, Brackett, Ridlon, Porter Ryerson Lovett, Hibbs, Albee Putti Campbell Steindler, Mixter Barr and many others

I am grateful to the editors of The Journal of Bone and Joint Surgery, Surgery, Gynecology and Obstetrics, The Journal of the American Medical Association, Today's Health (Hygeia), and other medical publications for permission to reproduce illustrations and manuscripts

I am thankful to many persons whose names are not mentioned specifically but are credited throughout the book The same is true of several medical publications I wish to express my appreciation to the Office of the Surgeon General of the United States Army for the use of certain material I thank the S H Camp Company for permission to reproduce several anatomic illustrations by Tom Jones I express thanks to Doctors Campbell, Steindler and many others who loaned me several original illustrations

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PHILIP LEWIN

CHICAGO ILLINOIS

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BASIC CONSIDERATIONS

THE BACK AND ITS DISK SYNDROMES

Part I

Basic Considerations

CHAPTER I

INTRODUCTION

THE foundation of this book is the close personal experience with over 40,000 "back cases."

The author has been on the alert at all times for accurate indicators of specific lesions. I omitted the chapters on the neck (because of lack of space) in spite of the striking similarities between disorders of the back and the neck, of the frequency of concomittant involvements, of the frequency of concurrent involvements.

The disks have taken the play away from the facets, the foramina, arthritis, lumbago, idiopathic or symptomatic sciatica, sacroiliac subluxation and spondylolisthesis.

There is no doubt that the basis of most surgical procedures and the success obtained is due to the recognition and fulfillment of Hibbs' work. He led the way in deskeletalization of the vertebra, and then gouging flakes and chips of bone to make raw bleeding surfaces so that when contact is made and maintained, a fusion occurs.

Backache has always been an important affection of mankind. Its chief causes are congenital defects, traumatic injuries, arthritic affections, postural errors, infectious, metabolic and neoplastic factors. The practical importance of congenital defects is the fact that they lay the groundwork for a superimposed injury or infection. Postural backache is due to static errors resulting in muscular and ligamentous strain due to improper alignment. The spine is the seat of abnormalities that modify the normal mechanics, and predispose to stress, strain, weakness and disease. Variations in the number and shape of vertebræ found in apparently normal individuals predispose to backache. Anomalies of the vertebræ may cause no symptoms until their alignment has been disturbed by trauma.

Traumatic causes of backache include fracture, fracture and dislocation, lesions of the intervertebral disks, Kummell's post-traumatic spondylitis, railway spine, concussion of the spine or spinal cord or brain, epiphysitis, coccyx disturbances and rupture of muscles, ligaments or fasciæ. Neglected minor injuries may be followed by arthritis.

Infectious lesions include tuberculosis, syphilis, osteomyelitis, infectious arthritis, blastomycosis, actinomycosis, oidiomycosis and undulant fever. Tumors of the bones include carcinoma, hypernephroma, Hodgkin's disease, osteoma, and myeloma. Tumors of soft tissues may involve the spinal cord and meninges.

Pain due to gynecological conditions may be grouped as displacements, pelvic inflammations and tumors. Overburdening of the female vertebral column during pregnancy is one of the causes of pain. A gynopathic backache is an intermittent postural spastic condition located at the sacro-lumbar articulation, involving the lower erector spinae and upper iliopsoas muscle segments.

It is important to recognize cases of pre-existing abnormalities or disease that have been made worse by slight or moderate injury. Pathological changes may be the result of traumatic, mechanical, chemical, infectious, neoplastic or circulatory factors.

Symptoms of back disturbances depend upon the cause and the peculiar disturbance of the particular structure which is affected. The presenting symptom is pain which may be local or referred. Symptoms which cause disability are pain, stiffness and weakness.

Varied pathological conditions may give rise to similar complaints of pain, weakness and limited motion, while careful study reveals objective evidence of many distinct lesions. The term internal derangements of the back includes those mechanical disturbances involving especially the articular facets and the intervertebral disks.

No back examination is complete without an examination of the bare *feet while standing. In addition deformity*, imbalance and muscle weakness should be looked for. The most important symptom, however, is pain which is referred along the courses of the spinal nerves to the gluteal region, hip, thigh, calf and heel. The knee and achilles jerks may be diminished or absent and there may be hypesthesia, gluteal atrophy and pelvic imbalance.

The physical examination must be carried out meticulously in a routine manner to avoid overlooking important lesions. All deformities must be analyzed mechanically. For the clinical examination backache may be divided into those cases with neurological symptoms and those without such symptoms.

Roentgen ray examination includes good roentgen photography and adequate area coverage. Antero-posterior and lateral views may in certain cases be supplemented by special projections, stereoroentgenography or life-size roentgenography.

Differential diagnosis of back conditions must consider the exact location and the specific lesion. The difficulty in many instances is to determine the exact cause of the lesion. One must determine whether the lesion is infectious, traumatic, arthritic, mechanical, neurological or neoplastic.

Many neurological conditions affecting the function of the back can be differentiated by a simple and brief examination of the back, foot, ankle *and leg. The equipment required to test for these conditions are*: a pin, a percussion hammer, wisp of cotton, hot and cold water in test tubes, and a sense of touch. It is surprising how often a patient will report simple

symptoms of minor disturbances that turn out to be indications of serious neurological lesions

Some of the neurological conditions affecting the back and leg include anterior poliomyelitis, peripheral neuritis, Friedreich's ataxia, tabes dorsalis, Charcot's disease, central nervous system lesions, spina bifida, peripheral nervous system lesions, spinal nerve lesions, causalgia, neuritis, hysteria, exaggeration and malingering

A revolutionary advance in the conception of back disorders was the introduction of the lesion known as protrusion of an intervertebral disk. The announcement of Mixter and Barr inaugurated an era. There is a growing appreciation of the significance of this lesion. The disks make up a full quarter of the total length of the spinal column. It may be said that the majority of traumatic conditions resulting in derangement of spinal function are primarily due to involvement of the intervertebral disks. For this point of view we are indebted to the late Professor Schmorl, whose work developed a fundamental approach to pathological conditions involving the disk. He studied between 8000 and 10,000 spinal columns.

The part played by protruding disks in the production of neurological symptoms is receiving increasingly wide recognition. According to Love and Camp there has been a tremendous increase in the percentage of protruded disks as compared with that of neoplasms of the spinal cord. This change has been brought about by increased ability to diagnose such lesions early.

The most important factor in the treatment is the time element. Treatment is based on the fundamental principles of rest and protection followed by proper physical therapeutic measures to effect a cure. Rest in bed is beneficial to many patients suffering from backache. Support is needed in many cases, exercise and proper anatomical posture by the majority.

Goldthwait's contribution concerning gynecological trauma to the back, his work on the intervertebral disks and his writings on sacro-iliac lesions and manipulations of the spine, are significant milestones of progress. Other milestones include the newer concepts regarding the intervertebral disks. The improvements in diagnosis of spinal cord and vertebral tumors, the concepts of Schmorl and Junghanns, the perfection of the Hibbs and the Albee technics of operation and their modifications, are highly significant. The greatest advances from the roentgen-ray point of view include improved apparatus and technic. Laminagraphy, and such contrast media as pantopaque and air myelography are valuable diagnostic aids.

Milestones in diagnosis are, chiefly, improvement in the elicitation of special signs and tests, a clear conception of their interpretation, and neurological precision in localizing organic lesions involving the central and peripheral nervous systems. Intraspinal protrusions of intervertebral disks account for many cases of hitherto unexplained intractable pain and especially those pains occurring in the low back and along the course of the sciatic nerve and its components.

Love and Camp emphasized the fact that there are no physical, neurological or orthopedic signs which are found exclusively in cases of protrusion of intervertebral disks. All signs and symptoms may be found in other conditions also. Men of experience can recognize the disk cases

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Analogies The vertebral column is like a circus tent pole. The central pole stands upright. It has numerous guy ropes, each secured to the ground by stakes, each is secured at the top to keep the [illegible]. Trouble can occur at either the top or bottom or at any point in between.

The lumbosacral juncture is an area where the movable element (a train of railroad cars, the vertebrae) bumps into the immovable structure (the sacrum) which is like the solid stop in a railroad station. Something must "give." It is usually the cars (vertebrae or the disks).



Fig 2.—Rhomboid of Michaelis. (De Lee and Greenhill, Textbook of Obstetrics, courtesy of W. B. Saunders Company.)

Concussion at the Lumbosacral Juncture.—You can get concussion from a forcible sitting down thrust.

The Carpenter's Loose Hammer.—When the head becomes loose, the carpenter tightens it by striking the end of the handle against a rigid surface.

Automobile Concussion.—When auto No. 1 stops at a stop sign and auto No. 2 crashes into No. 1 from the rear, some concussion harm occurs. In addition to damage to metal something human must "give," and it is usually at the lumbo-sacral juncture and in the neck.

A Nutcracker Squeezing Tissue.—A nutcracker must have two jaws to exert pressure. A pair of pliers would be worthless without two jaws. The word "clamp" used as a noun implies two jaws.

There is no doubt that orthopedic surgeons have permanently "locked" thousands of intervertebral disks in place with relief from symptoms when they performed fusion operations.

Oftentimes the abnormalities that are visualized in the *x*-ray are old and might not be causing the patient's present symptoms or signs. They may or may not be related to the trouble under investigation. Every time a physician examines *x*-rays, he should ask himself this question "What is wrong with this patient in addition to what I see in the *x*-rays?"

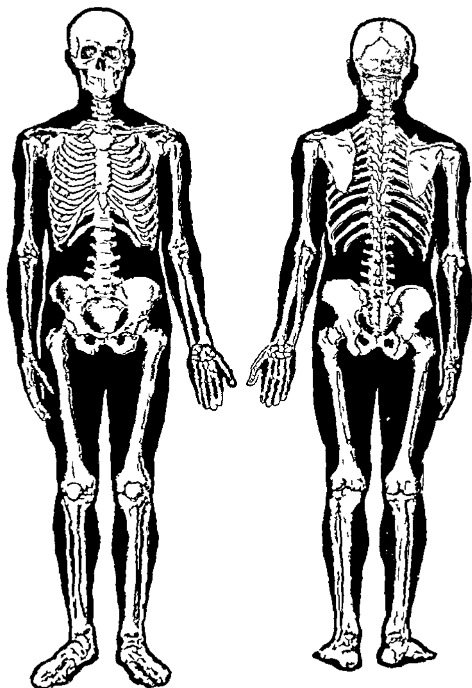


Fig. 1. The skeleton viewed from the front and back. (After Eycleshymer and Jones.)

of the system of blood supply to bones, are blood, the blood vessels and the content of the vessels. Sludge in the vessels is like carbon in the piston rings and valves of an auto. It represents the difference between good gasoline, oil and grease as compared with poor materials. The effect of certain drugs is comparable to a fresh "grease job" or grinding the valves.

Mechanics.—A person with a backache is like an automobile that is rattling (Dickson). A second hand auto rattles more than a new one. A broken down auto rattles more than either.

Electrical Cable.—Electrical engineers boasted when they succeeded in perfecting two-way conversation over the same wire or cable. The spinal cord makes that accomplishment look like a toy electric train. The TV co-axial cable is a toy compared to the spinal cord. There are human "trouble shooters" who diagnose and localize the trouble.

Rupture of ligaments is like tearing a bed sheet or a piece of muslin. It produces hemorrhage and edema. The fluid is not pure water. It is like the application of a layer of glue which binds tissues together forming adhesions.

Twist or Torsion

It is the pivoting of the pelvis that causes the back trouble.

It is the twist or stretch that does the damage.

It is the torsion that produces the protrusion.

It is the rotation that produces the herniation.

The term microtraumatic means repeated multiple minimal trauma.

Disks wear out before the vertebrae as a rule.

A diesel engine can wear out or there would not be repair shops for them.

Removal of one disk does not prevent another from giving trouble any more than removal of one tooth will always save another.

The importance of x-rays lies in their interpretation and an evaluation of the findings. Two negatives do not make a positive diagnosis.

1 Insert a person's thumb in a vise
2 Turn the handle until the pain is unbearable that is like sciatica
3 Make one more complete turn that is like a disk

If you cannot get an object out of the jaws you should remove one jaw

Arthritis —Treatment is aimed at removing hurdles, hazards irritants and rough spots Imagine a freshly plowed field before and after a heavy

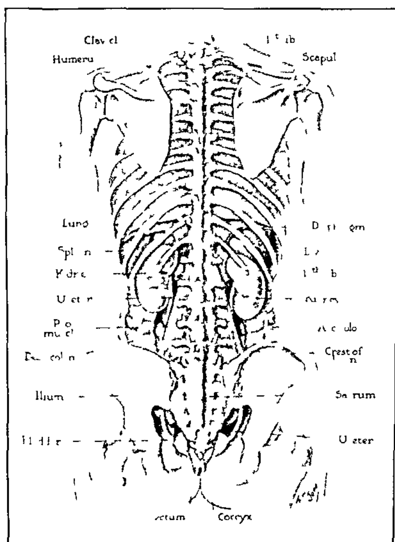


Fig 3 —Posterior view of the back thorax and pelvis (Courtesy of S H Camp and Company)

rain Before the rain there are deep furrows and many rough spots after the rain the furrows are shallower and the spots are smoother

Osteoporosis —In osteoporosis the bone is like sponge-candy instead of like normal curb tone bone The former is vulnerable to stress and strain weight and pressure

Circulatory and Vascular Disorders —A water supply is vital to survival of the plants The dictum is "No water—no garden" The components

Ossification of the spinal vertebræ begins, according to Broman, in a 33 to 34 mm embryo in the arches of some vertebræ Single ossification points are seen in a 34 mm embryo in the bodies of lumbar and thoracic vertebræ During the first year of life the two ossification centers of the vertebral arch fuse with each other to become one whole and from three to six years of age this ossified arch fuses with the ossification centers in the body Hanson considers that the bony substance of the fully developed vertebra is derived from the paired ossification point in the vertebral arch

GROWTH AND DEVELOPMENT OF THE VERTEBRÆ

According to Lambertz it is only after the fourth month of fetal life that one is able to discern two plates of denser structure, one upper and one lower Between these there is a lighter zone where the cartilage is being absorbed and ossification begins

Hanson states that 'from late fetal life till the age of two years the vertebral body appears on a lateral roentgenogram is divided into three plates one upper and one lower of denser nature and one of lighter texture between them In the anterior margin of the latter there is seen an excavation in the shape of an amputated cone with its base directed anteriorly The excavation is occupied by a vein running close under the perichondrium and periosteum respectively and continuing by a stem on each side of the mid line towards the foramen vertebrale During the second year of life the excavation disappears except in the lower 5th and 7th thoracic vertebra and in the 1st and 2d lumbar vertebra where it remains till the age of fourteen Canal formations may appear in different forms during the ages two to fourteen In some individuals the vertebral body has a staircase-like outline at its two anterior corners The epiphyses develop in these staircase-like formations Hanson has found this kind of vertebra in persons with round backs

Hanson has found epiphyses in a child aged six years He found the canal formations in all the cases examined, both in feti of 35 cm length and in individuals up to the age of fourteen They are found to be largest in tuberculous vertebra

Among 1520 human vertebral columns studied by Willis in the Hamann Museum of The Western Reserve Medical School, more than 5 per cent showed a separate neural arch in one of the lumbar vertebræ usually the last In vertebral columns with twenty-five presacrals, the incidence of this separate neural arch is almost twice as great as in columns with the regular twenty-four, but the actual percentage in both series is not constant for the population at large Willis states that study of the defect substantiates its essential origin in a skeletal anomaly and assigns a very minor rôle to trauma Embryologically the defect falls into the category of anomalous ossifications It may be found in any lumbar vertebra and on either or both sides, but is usually confined to the last presacral Trauma plays a secondary role in the condition

A separate neural arch in its origin resembles a spina bifida Defective articular processes, and separate bony centers for transverse, mammillary and accessory processes are unique in the lumbar column

CHAPTER 2

EMBRYOLOGY OF COMPONENT STRUCTURES OF THE BACK

In order to understand the pathological changes occurring in the human back and evaluate clinical symptoms and roentgenological changes, one should have some knowledge of the embryological development of the component parts of the spine and back. From the mesoderm are derived the muscles and the vertebral body, cartilage plate and annulus fibrosus of the spinal column. The notochord, an ectodermal structure, becomes surrounded by mesenchymal cells which migrate from the sclerotomes. The cells farther away in the intervertebral regions remain undifferentiated and form the *anlage* of the intervertebral disks.

At about the tenth week cartilage cells make up the vertebral bodies and ossification centers appear between the tenth and the fifteenth week. By this time all the cells of the notochord have been extended from the region of the vertebrae and are confined to the center of the intervertebral disks. Differentiation can now be made between the nucleus pulposus and the annulus fibrosus.

Each vertebra has five centers of ossification, one for the body and one for each lamina and its process. The vertebral arch forms during the first year by the fusion of the two posterior centers of ossification, but is not joined to the center of ossification of the vertebral body until the third year, leaving three main centers. In these centers the process of ossification begins at the fortieth day of life but does not end until adolescence.

The three primary centers form the neural arch, the costal process and each half of the center of the body of the vertebra. Fusion of the center *of the body of the vertebra with the arch occurs between the fourth* and fifth years, and in the sacrum between the fifth or sixth years of life. Secondary ossification centers appear later. Those of the epiphyses appear at the upper and lower surfaces of the vertebral bodies from the eleventh to the fourteenth year and fuse with the bodies some time between the eighteenth and twentieth year. Secondary ossification centers appear for the costal elements of the cervical and lumbar sections, for the nuclei of the ribs and for the tips of the spinous and transverse processes.

Keith says: "The lateral limbs of the cartilaginous bow meet behind in the neural canal in the fourth month, thus completing the neural arch. One center of ossification appears in each limb of the neural arch at the eighth week. There are three centers of chondrification for each half vertebra, one for the neural arch, one for the costal process and one for each half-centrum." According to Gray, the vertebral arch forms during the first year by the juncture of the two posterior centers of ossification, but the arch is not joined to the center of ossification of the vertebral body until the third year.

These opinions were confirmed in general in the fetal spines dissected by Willis. There seemed to be an intermediate stage of calcification of cartilage, prior to actual osteogenesis, and into this calcified cartilage the real bone centers developed following the blood vessels. Roentgenograms at this stage showed the structure to be radiopaque, but with no bone architecture surrounding the ossification centers. In strong transmitted light

Fig. 5.—Skeletal Maturation. Time of appearance of *centers of ossification*. Upper heavier figures refer to males, lower lighter figures refer to *females*; *single set of figures* applies to both sexes. A B indicates center is + at birth. *Figures in parentheses* means approximate time of fusion. (Ross Golden, Diagnostic Roentgenology, Thos. Nelson & Sons.)

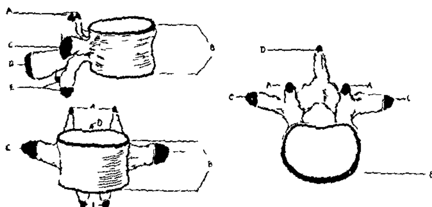


Fig. 6.—Diagram of the possible locations of persistent vertebral epiphyses. (Bailey and Curtiss, courtesy of Calif. & West. Med.)

In summarizing the statements of various embryologists, it may be said that the membranous vertebral column is a continuous sheath of mesodermal tissue which begins to chondrify first in the centrum about the notochord during the fifth or sixth week. The vertebral bow chondrifies to form the lateral portions of the neural arch, the extremities of which unite dorsally about the *fourth month*.

The chondrified rudimentary spinous, transverse, and articular processes arise from this arch. Sclerotogenous tissue which does not chondrify

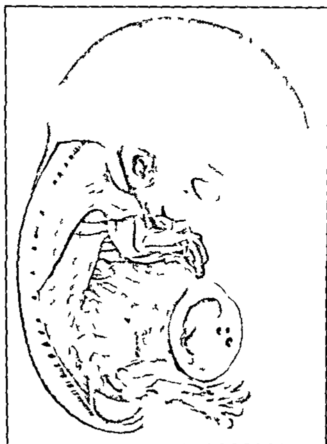


FIG 4 Drawing from a reconstruction of an embryo 20 mm, age about seven weeks. Considerable ectoderm and superficial tissues have been removed. The muscles and nerves are readily recognized. (Bardeen and Lewis, Am. J. Anat.)

remains to form the ligaments uniting the laminae of adjacent vertebrae. At the seventh or eighth week a single center of ossification appears in each half of the neural arch near the base of the superior articular process, evident first in the cervical portion of the column. This extends forward to the centrum, with which it does not fuse until the fourth or fifth year, and backward to the transverse process, laminae and spinous process. Osseous fusion of the spinous process begins at full term, extending upward from the lumbar region to reach the cervical area at the fifteenth month. Interruption of this posterior fusion results in spina bifida.

one or more vertebrae. Under this stimulus these transverse processes enlarge, fuse and become the sacrum. The points of attachment become the sacro-iliac joints. Frequently this articulation is bilaterally asymmetrical. Willis points out that within each animal species there are variations as to the particular vertebrae with which the ilia articulate. In addition, there is either progressive or retrogressive fixation of the pelvic complex to the vertebral column, appearing in different zoological species derived from common ancestral types.

In the phylogenetic development of man, the pelvis has progressed toward the head by incorporating in the sacrum the successive last lumbar vertebra. Thus the next preceding segment assumes the characteristics of the last lumbar segment.

The spinal column of the newly born human infant, like that of the quadruped, presents a single curve, *i. e.*, a backward convexity. When the infant extends his neck, a cervical curve develops and when he extends his hips, a lumbar curve becomes evident.

THE VERTEBRAL-RING APOPHYSIS

Bick and Copel describe the vertebral ring apophysis as a narrow mound which encircles the rims of the upper and lower surfaces of the vertebra. It is at the site at which branching fibers from the long intervertebral ligaments insert into the individual vertebra. These fibers exert traction at their points of insertion. It is a radiolucent cartilaginous prominence following the margins of adjacent surfaces. This circle calcifies at about six years of age, begins to ossify at about thirteen years, and begins to fuse with the body mass of bone at about seventeen years. At eighteen years fusion is complete.

OSTEOHISTOLOGY OF NORMAL HUMAN VERTEBRA

From his anatomical observations in fifty specimens Bick found that a reference to the progressive and normally varied osteohistology of the human vertebra is essential to a proper understanding of the effect of internal and external mechanical and pathologic influences on the human spine.

The vertebral body grows longitudinally as does the diaphysis of a long bone of the extremities, but without appended epiphyses. Since the columnar cartilage plate of all such bones marks the advance of diaphyseal ossification rather than actual skeletal growth, and since such growth can take place, as in the vertebra, in the absence of an appended epiphysis, the term diaphyseal plate is more appropriate than epiphyseal plate.

Since the vertebral body possesses the same diaphyseal plates as do the long bones, they are subject to the same internal or environmental influences.

Since the peripheral ring of the cephalic and caudal surfaces of the vertebral body, commonly but erroneously referred to as the vertebral epiphysis, meets rather the requirements by definition of a traction apophysis, and fails to meet those of an epiphysis, lesions ordinarily operable

there appeared to be two separate areas of dense bone in each half arch connected by a narrow isthmus just distal to the developing superior articular process.

Early in fetal life, the ilia developing in the hind-limb buds approach the vertebral column and become attached to the transverse processes of

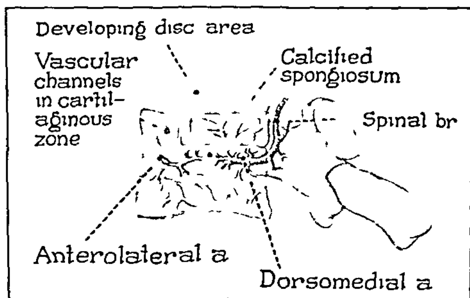


Fig. 7.—Ferguson's interpretation of a sagittal section through the mid body of a six month fetus. (*Calcified spongiosum* on drawing = *substantia spongiosa of bone*.) (Ferguson, courtesy of Jour. Bone & Joint Surg.)

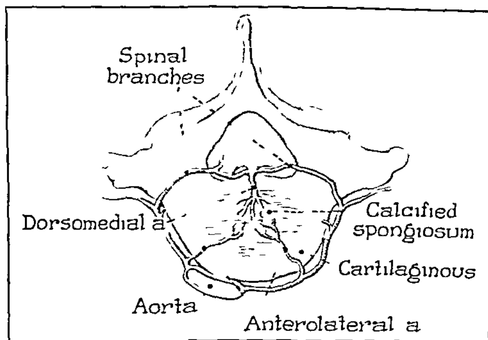


Fig. 8.—Ferguson's interpretation of a transverse section through the mid body of a six month fetus. (*Calcified spongiosum* on drawing = *substantia spongiosa of bone*.) (Ferguson, courtesy of Jour. Bone & Joint Surg.)

CHAPTER 3

ANATOMY OF THE BACK

The human back is composed of the vertebral column, ligaments muscles, fasciæ, blood vessels and nerves

The normal curves of the spine vary according to age Willis emphasized the fact that the spinal column of the infant is of the primate type Its hips are flexed and attempts to extend them are met with considerable resistance Forced extension of the hips through the action of the ilio-femoral ligaments and muscles on the sacro-iliac articulation throws the sacrum sharply backward When the limit of this motion is reached the same forces, plus that of the iliopsoas muscles arch the lumbar spine forward, at the same time intensifying the original curve in the thoracic area In the newborn, the vertebral column shows two primary curves, both concave forward The upper curve reaches from the head to the pelvis while the lower curve is made by the sacrum As erect posture and elevation of the head occur secondary curves appear the first being a forward convexity in the cervical region With standing and walking the lumbar region acquires its forward convexity These secondary curves allow the column to transmit the weight of the trunk to the pelvis almost entirely by bony support so as to minimize the muscular effort needed to maintain the erect attitude In females the lumbar curve is greater than in males With old age the spine tends to assume one anteriorly concave curvature

The spine consists of four regions cervical thoracic, lumbar and sacro-coccygeal

Vertebral Anatomy —Each vertebra is composed of a body or weight-bearing portion and a spinal arch with its accessory processes the function of which is to protect the spinal cord and provide attachment for muscles and ligaments The bodies move on one another by means of the intervertebral disks which have resistant semi-fluid centers but elastic compressible peripheral layers so as to permit motion or rotation in any direction The spinal arches articulate with one another by means of processes projecting upward and downward in pairs from each vertebra The intervertebral joints so formed are true joints lined with cartilage and surrounded by capsules with synovial membranes

Ligaments —The vertebræ are bound together by strong anterior and posterior ligaments extending from the sacrum to the occiput, and covering the bodies and the intervertebral disks The ligamenta subflava are strong elastic ligaments which run along the posterior surface of the spinal canal and are attached to the laminæ The interspinous and intertransversalis ligaments join the spinous and transverse processes, respectively

The Vertebræ in Various Regions —The cervical vertebræ are not described in this book The thoracic vertebræ have broad bodies, narrow and rounded vertebral foramina large transverse processes and frontally placed

only on epiphyseal structures cannot properly be ascribed to those found in this structure. This one therefore has been more suitably termed the vertebral ring apophysis.

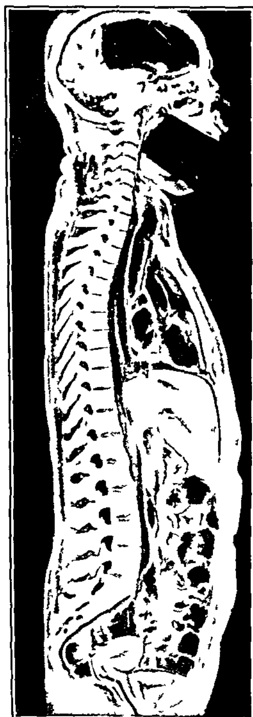


FIG. 9.—Radiograph of a sectioned cadaver that demonstrates from the lateral aspect the anatomy and primary curves of the vertebral column. (Reproduced through the courtesy of H. O. Mahoney, B. J. Anson, and R. I. D., Department of Anatomy, Northwestern University Medical School, Chicago, Ill., and Radiography and Clinical Photography, with personal permission of Professor Anson.)

and extension and lateral bending The 5th lumbar vertebra is larger than the others and has strong, bluntly wedge shaped transverse processes

Sacrococcygeal Region - The sacrum is a single bone representing the developmental fusion of its five vertebral parts The sacral canal is transversely flattened and runs through the posterior portion of the mass, opening on the dorsal surface of the sacrum somewhat proximal to its apex at the sacrococcygeal hiatus The anterior sacral foramina lead antero laterally from the sacral canal and permit passage to the sacral nerves, which are the nerves to be reached in sacral anesthesia Posteriorly

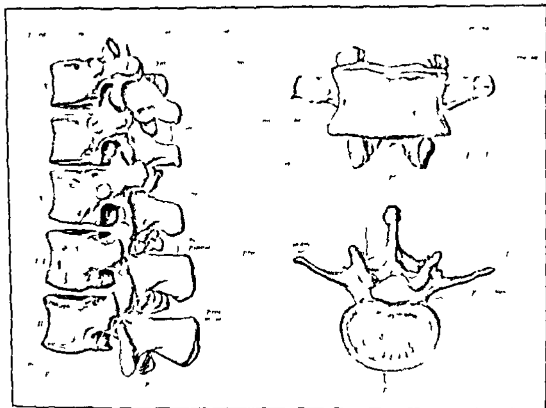


Fig 11 – Lumbar vertebræ seen from the side front and top (Sobotta and McMurrich)

at the entrance and exit of the canal are the lumbosacral and coccygeal spaces through which subarachnoid and extradural anesthesia, respectively, are induced

The base, or superior surface of the sacrum is constructed like an ordinary vertebra with two articular surfaces to match the inferior articular surfaces of the 5th lumbar vertebra Through that part of the sacrum which represents the fusion of the 1st, 2d and 3d sacral vertebræ, there is articulation with the ilium on both sides producing the sacro-iliac joints

Coccyx —The coccyx is the small, triangular, terminal segment of the spine, made up of the four or five incompletely developed distal vertebræ, joined to, and continuing in the curve of the sacrum The sacrotuberous ligaments continue their sacral attachments along the lateral borders of the coccyx

articular processes The articular processes are vertical and flat and face in the antero posterior plane, thus permitting flexion and extension, lateral bending and rotation At the same time each vertebra in this region supports a pair of ribs and the relation of the latter to the thorax results in considerable secondary limitation of motion, affecting flexion, extension and lateral bending The thoracic spinous processes point sharply caudad The lumbar vertebræ are larger and have no articular facets for ribs In the lumbar region the articular processes are normally crescentic in cross section and vertical This shape limits rotation but permits free flexion

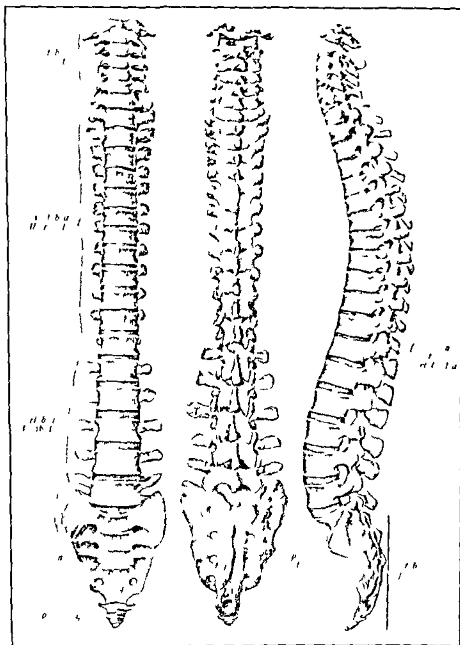


Fig 10 —The vertebræ (Sobotta and McMurrich)

The joint spaces are unevenly curved slits Articular surfaces are for the most part smooth, but have several irregular projections and depressions which normally lock and stabilize the joints Sacro iliac joints are synarthroses

Much of the support in this region is afforded by strong ligaments The bony surfaces posterior to the articulating surfaces are rough, for the attachment of these reinforcing ligaments The longitudinal depression behind the joint is crossed by the short, posterior interosseous ligament The long and short posterior sacro-iliac ligaments constitute a

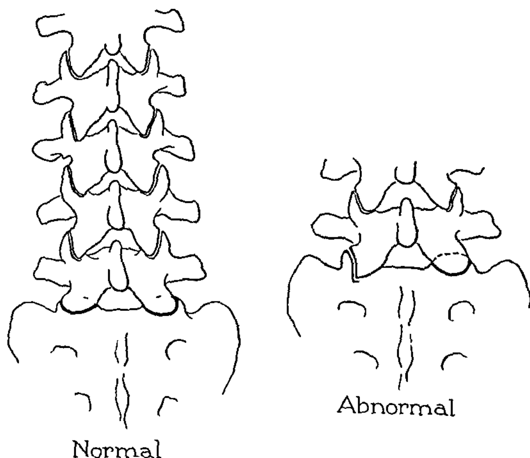


Fig 16 — Lumbar and lumbosacral articular facets

strong expansive mass of fibrous bands extending obliquely outward to the ilium from the lateral sacral crest They also reinforce the posterior joint line The sacrotuberous and sacrospinous ligaments, which arise from the whole area of the posterior sacro-iliac ligaments, are anchored into the ischial tuberosity and the ischial spine The anterior sacro-iliac ligament extends from the sacrum to the medial surface of the ilium as a group of thin, broad fibrous bands The iliolumbar ligaments extend from the transverse processes of the 5th lumbar vertebra to the posterior part of each iliac crest, acting as a hammock for this vertebra

The capsule of the sacro iliac joint is short and thin, and is reinforced anteriorly by the iliolumbar and anterior sacro-iliac ligaments The joint

The Sacro iliac Region — The sacro-iliac joints are the resilient buffers between the vertebral column and the lower extremities The joints are formed by the expanded portions of the sacrum, and the articular surfaces of the ilia The articulating surfaces of the sacrum are directed posteriorly and laterally, while those of the ilia are directed forward and medially

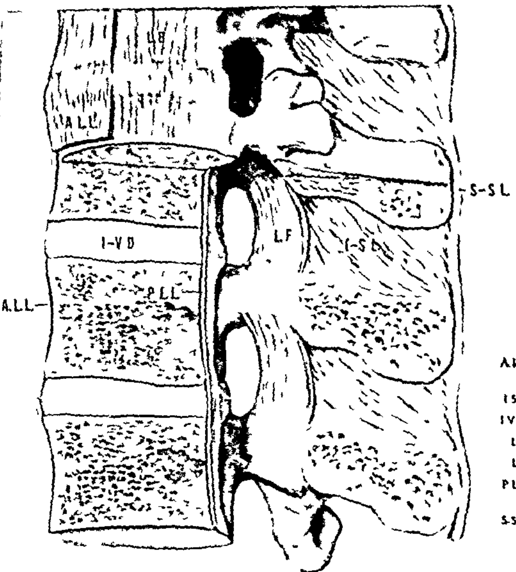
Fig 12 Fig 13

Anterior and posterior views of ligaments of the spine

Fig 14 Fig 15

Sagittal and linear cross sections of vertebræ

PLATE I



Ligaments of the Spinal Column (From *Ciba Collection of Medical Illustrations Vol I—The Nervous System*)

contains synovial fluid. Thus the sacro-iliac region is well supported by a cross hatching of powerful ligaments. The innervation of these ligaments was worked out by Pitkin and Pheasant.

Intervertebral Disk.—This structure is made of two parts: one, the peripheral or outer portion called the "annulus fibrosus," the other, the central portion called the "nucleus pulposus." The outer part is made up of concentric layers of connective tissue fibers, and assists in part in holding the vertebræ together but probably the more important function is to hold the central or pulpous portion confined so that its shape can be preserved. The central portion is an oval mass of fibrocartilage which flattens out under high pressure. This is placed a little back of the center of the disk and represents the central point upon which the weight of the body is balanced. The pressure under which this pulpous portion exists and upon

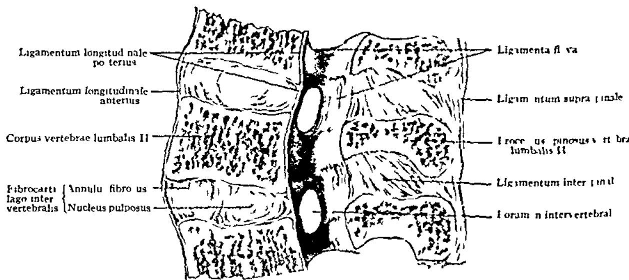


Fig. 17.—Sagittal section through the spinal column in the lumbar region to show the vertebral canal and the intervertebral disks and foramina. (Callander Surgical Anatomy, courtesy of W. B. Saunders Company.)

which its importance as the pivotal point in body movement must depend is readily apparent if a sagittal section of the spine is made when the pulpous portion bulges markedly, while the outer portion does not alter its position.

Blood Supply of the Vertebræ.—Wagoner and Pendergrass studied the intrinsic circulation of the vertebral bodies. The arterial supply of the bodies of the lumbar vertebræ is derived from the lumbar arteries and their branches. These arteries arise in pairs from the posterior wall of the abdominal aorta and pass posteriorly. After they penetrate the anterior muscle group, the dorsal branches arise and continue posteriorly in the horizontal plane, one on either side of the vertebral body just above the midline. Those branches which penetrate directly into the bone arise from the medial surface of the rami dorsali, as they lie in contact with the vertebral body, and these branches penetrate directly into the bone. These arteries may be followed well into the middle of the vertebral body before

Lumbodorsal Fascia.—This is a deep investing membrane which covers the deep muscles of the back of the trunk and continues upward on the back of the neck. In the thoracic region it is a thin fibrous lamina which binds down the extensor muscles of the vertebral column and is attached to the spinous processes of the thoracic vertebræ and angles of the ribs.

Callander considers the three divisions of the lumbodorsal fascia as fusing laterally to the erector spinæ and quadratus lumborum muscles into

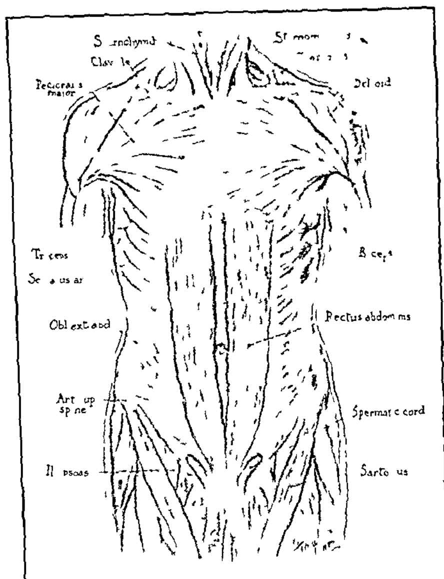


Fig. 20.—Superficial muscles in the male, anterior view. (Courtesy of S. H. Camp Company.)

a broad aponeurosis which extends anteriorly as the transversus abdominis muscle. The *posterior layer* is the thickest, originating over the lumbar spinous processes and the supraspinous ligaments, and investing the erector spinæ muscle dorsally by a strong fascial sheet. This lamella is covered by the latissimus dorsi and the serratus posterior inferior muscles, to which it partly gives origin.

The Middle Layer is attached to the posterior surfaces and tips of the lumbar transverse processes and lies in front of the erector sp [illegible]

The intrinsic venous circulation of the vertebral bodies consists of a large sinusoidal plexus with many ramifications The dorsal spinal veins are connected with the posterior longitudinal meningo-rachidean veins by way of channels running between the spinous processes The anterior longitudinal meningo rachidean vein is directly connected by many branches which surround the spinal cord and meninges The anterior veins lying in close proximity to the posterior surface of the vertebral bodies,

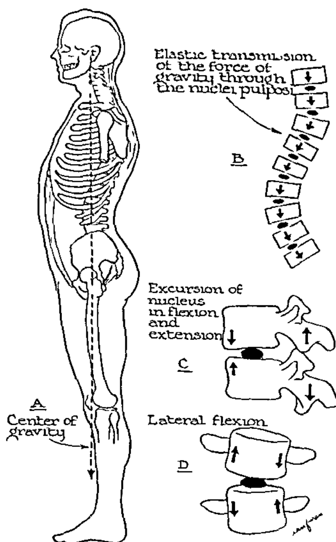
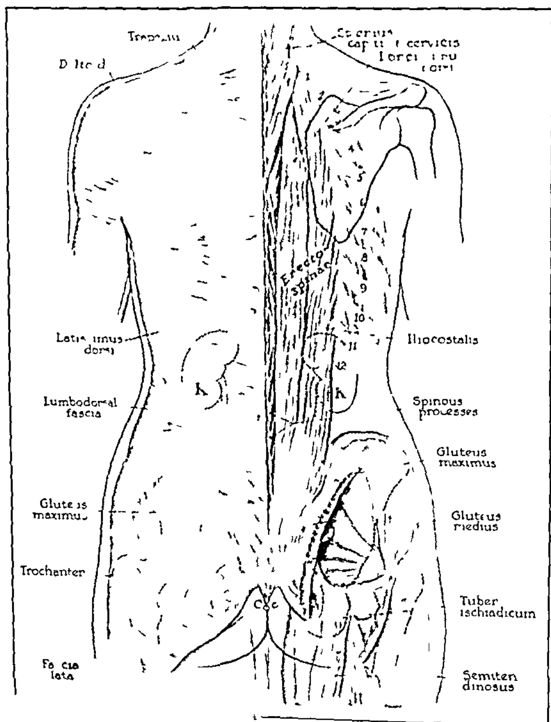


Fig 19 —The mechanics and dynamics of the intervertebral disk Balance and transmission of forces (Adapted from Calvé and Galland) (Redrawn and modified)

lead directly to the venous sinuses within the body of the vertebra and these in turn join with the longitudinal veins on the anterior surface of the vertebral bodies

Wagoner and Pendergrass stress the fact that the sinusoidal tract is filled with hemopoietic tissue and constitutes a cellular bed through which arterial blood percolates and from which venous blood is collected This arrangement, no doubt has some effect upon the localization of disease processes and their mode of extension within the vertebral body

Group consists of the latissimus dorsi posteriorly and the external oblique laterally. After arising from the outer ridge of the iliac crests, from the lumbar and sacral spinous processes and from the thoracic leaf of the lumbodorsal fascia the latissimus dorsi converges superiorly and laterally to attach by a flat tendon into the bicipital groove of the humerus. The external oblique fibers arise from the 9th, 10th and 11th ribs, descend obliquely downward and forward and form a free posterior margin on the back.



... in the female posterior view (Courtesy of ... pany)

layer is strengthened by the posterior lumbocostal ligament, which connects the transverse processes of the 1st and 2d lumbar vertebræ to the outer margin of the lowest rib

The Anterior Layer is the weakest and arises from the anterior surfaces of the lumbar transverse processes and their bases and forms an anterior

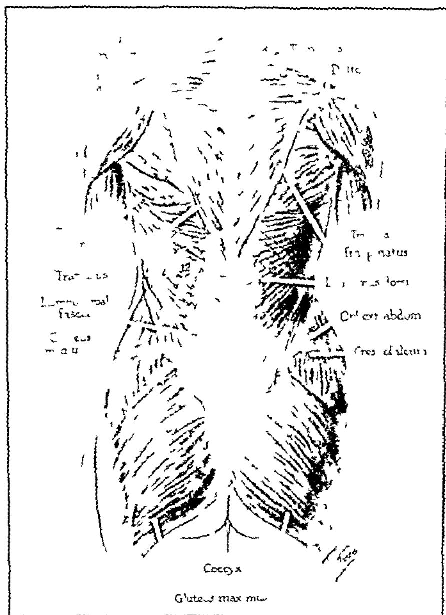


FIG. 21 —Superficial muscles of the trunk in the female posterior view (Courtesy of S H Camp and Company)

investment for the quadratus lumborum muscle In its upper portion this layer is strengthened by the lateral lumbocostal ligament and serves as the origin for some of the fibers of the diaphragm

Posterior Abdominal Muscles —The posterior abdominal muscles are divided into superficial middle and deep muscle groups *The Superficial*

into the 12th rib after narrowing somewhat. This muscle is in the fibrous compartment formed by the middle and anterior lamellæ of the lumbothoracic fascia. The psoas major muscle lies in the groove formed by the bodies and transverse processes of the lumbar vertebræ. It arises from the 12th thoracic and all the lumbar vertebræ and passes downward and laterally along the pelvic brim. It proceeds beneath the inguinal ligament, entering the thigh to insert into the lesser trochanter of the femur. The posterior portion of the transversus abdominis muscle arises from the fusional aponeurosis of the three leaves of the lumbothoracic fascia.

The Spinal Cord and Nerve Roots.—Up to the third month of intrauterine life, the spinal cord occupies the entire length of the vertebral canal. From this time on, the column lengthens more rapidly than the spinal cord, so that the cord appears to "shrink upward in the vertebral

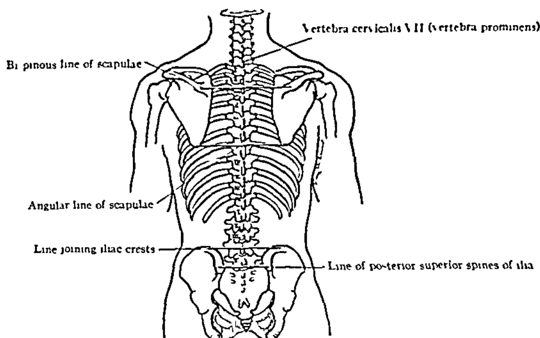


FIG. 24.—Landmarks of the back. (Callander: Surgical Anatomy, courtesy of W. B. Saunders Company.)

canal" (Callander). At birth the lower end of the cord is opposite the body of the 3d lumbar vertebra. In the adult, the lower level of the cord is opposite the lower level of the 1st or the upper level of the 2d lumbar vertebra. The lower limit of the cord (conus medullaris) leads into the terminal filament which continues downward within the vertebral canal and actually anchors the medulla to the coccyx. Alongside this filament run the fibers of the cauda equina, which emerge at the various lumbar and sacral levels, from the vertebral canal.

Each spinal nerve is attached to the spinal cord by an anterior and a posterior nerve root. The *anterior nerve roots* are purely motor, and emerge in series from the anterior gray column of the cord. The *posterior (dorsal nerve roots)* are purely sensory and enter the spinal cord in series on its posterolateral aspect. Each posterior nerve root contains a *ganglion*, whose cells give rise to central and peripheral fibers. The ganglia of all but the sacral and coccygeal nerves lie within the vertebral canal. Each pair of

The Middle Group consists of the sacrospinalis (erector spinae), internal oblique, and serratus posterior inferior muscles. The sacrospinalis muscle lies in the aponeurotic compartment formed by the dorsal and middle layers of the lumbodorsal fascia occupying the groove along the spinous processes from the sacrum to the neck. The internal oblique and serratus posterior inferior do not appreciably contribute to the essential musculature of the back other than taking origin within the region.

The Deep Muscle Group includes the quadratus lumborum, psoas major and the origin of the transversus abdominis. The *quadratus lumborum* muscle arises from the iliolumbar ligament below the iliac crest. It inserts

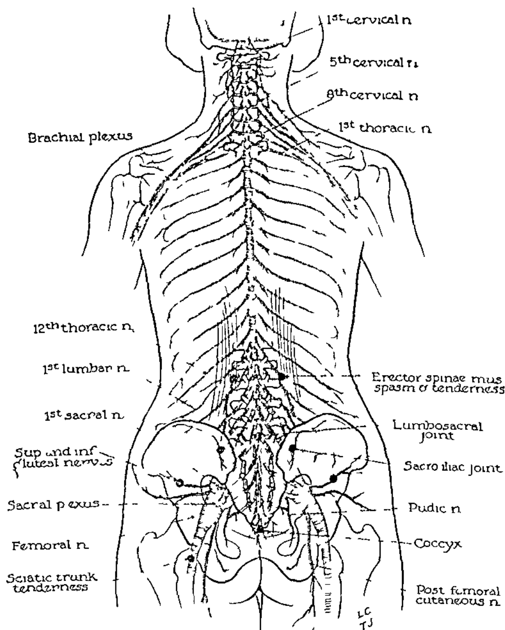


Fig 23.—Relation of posterior spinal nerves to cervical and lumbar vertebræ with indications of important landmarks and other structures. (Redrawn and modified from Tom Jones courtesy of S. H. Camp and Company.)

into the 12th rib after narrowing somewhat This muscle is in the fibrous compartment formed by the middle and anterior lamellæ of the lumbothoracic fascia The psoas major muscle lies in the groove formed by the bodies and transverse processes of the lumbar vertebræ It arises from the 12th thoracic and all the lumbar vertebræ and passes downward and laterally along the pelvic brim It proceeds beneath the inguinal ligament, entering the thigh to insert into the lesser trochanter of the femur The posterior portion of the transversus abdominis muscle arises from the fusional aponeurosis of the three leaves of the lumbothoracic fascia

The Spinal Cord and Nerve Roots —Up to the third month of intrauterine life, the spinal cord occupies the entire length of the vertebral canal From this time on, the column lengthens more rapidly than the spinal cord, so that the cord appears to shrink upward in the vertebral

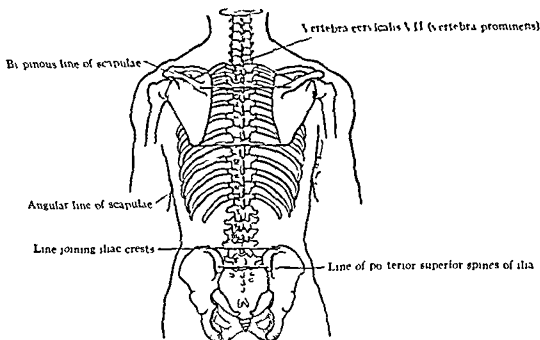


Fig 24 —Landmarks of the back (Callander Surgical Anatomy courtesy of W B Saunders Company)

canal (Callander) At birth the lower end of the cord is opposite the body of the 3d lumbar vertebra In the adult the lower level of the cord is opposite the lower level of the 1st or the upper level of the 2d lumbar vertebra The lower limit of the cord (conus medullaris) leads into the terminal filament which continues downward within the vertebral canal and actually anchors the medulla to the coccyx Alongside this filament run the fibers of the cauda equina, which emerge at the various lumbar and sacral levels, from the vertebral canal

Each spinal nerve is attached to the spinal cord by an anterior and a posterior *nerve root* The *anterior nerve roots* are purely motor and emerge in series from the anterior gray column of the cord The *posterior* (*dorsal nerve roots*) are purely sensory and enter the spinal cord in series on its posterolateral aspect Each posterior nerve root contains a *ganglion* whose cells give rise to central and peripheral fibers The ganglia of all but the sacral and coccygeal nerves lie within the vertebral canal Each pair of

nerve roots unites to form a *spinal nerve* within or near the intervertebral foramen The nerves divide almost immediately to form an anterior and a posterior branch (primary division) Both divisions contain sensory and motor nerves At about the region of the division the recurrent branch to the meninges and cord is given off The spinal nerve unites with a branch of the sympathetic trunk just proximal to this point

Just before the root reaches the dura, it receives an investment from the pia mater and another from the arachnoid Within the subarachnoid space the roots are surrounded by cerebrospinal fluid Outside the space they are surrounded by dura, which also includes the ganglion on the posterior root

IDENTIFICATION OF VERTEBRÆ

Surface Anatomy Levels

The identification of specific vertebræ can be determined by reference to certain landmarks of surface anatomy, and by definite guides as shown in *x*-rays Moreover some of the levels of the internal organs can be determined by their relation to certain bony landmarks

Any vertebra may be identified by counting down from the 7th thoracic or up from the 4th lumbar vertebra or from the 12th thoracic which articulates with the 12th rib The spinous process of the 7th cervical vertebra is often quite prominent although that of the first thoracic vertebra may be still more so The root of the spine of the scapula is opposite the spinous process of the 3d thoracic vertebra and the inferior angle of the scapula is opposite the space between the 7th and 8th thoracic vertebræ The spine of the 4th lumbar vertebra is on a level with the highest points of the iliac crests The spinous process of the 5th lumbar usually forms a slight depression The 3d sacral vertebra is at the level of the tops of the sacro iliac joints

In the thoracic region the obliquity of the spinous processes causes the tip of each to be opposite the body of the vertebra next below it The spine of the 2d thoracic vertebra corresponds to the head of the 3d rib but the 11th and 12th thoracic spines are opposite the heads of the 11th and 12th ribs, respectively The spinous processes of the lumbar vertebræ are opposite the lower parts of the corresponding bodies and the disks below them

In the adult, the spinal cord ends at the lower border of the 1st lumbar vertebra In children the cord terminates at the lower border of the 3d lumbar vertebra The following guides may be furnished by the vertebræ to locate the site of lesions of the spinal cord which are affecting any special nerves or set of nerves The interval between the occiput and the 6th cervical spine marks the origin of the eight cervical nerves that between the 6th cervical and the 4th thoracic spine marks the origin of the first six thoracic nerves between the 11th and 12th thoracic spines the five lumbar nerves arise as the upper part of the cauda equina while the origin of the five sacral nerves corresponds to the 12th thoracic vertebra The spinal meninges end at the level of the 3d sacral spine

The level of the high point of the iliac crests crosses the spinous process of the 4th lumbar vertebra The line joining the postero-superior iliac spines marks the middle of the 2d sacral vertebra

CHAPTER I

PHYSIOLOGY AND BIOMECHANICS OF THE BACK

The function of the back is to supply stability, flexibility, extensibility, lateral movements and rotation The vertebral neural arches protect the spinal cord The intervertebral disks act like bumpers on an automobile, *i e*, to minimize the shocks and jars to the brain, spinal cord and nerves Although the range of movement of the spine is considerable, any undue movement beyond the normal range may unduly compress the intervertebral disks or cause fractures of the bodies of the vertebræ, resulting in injury to the spinal cord or its nerve roots

Spinal Column (Vertebral Column) —The vertebræ are enveloped and bound together by strongly resistant ligaments, balanced by strong active muscles The articulation of the bodies of the vertebræ is accomplished by means of the intervertebral disks, while the articulation posterolaterally is through the articular processes The spinal column acts as a protecting case for the delicate spinal cord It is arranged in a series of elements with the bodies ventrally and the arch portion, dorsally placed This particular series of bony elements in the cervical region approximates one-sixth of the entire length of the spinal column In the thoracic region it is approximately one-half the entire length and in the lumbar region approximately one-fourth Of this entire series of vertebræ in the cervical, thoracic, lumbar, and sacral regions, one-fourth of the entire length is made up of the intervertebral disks, or cushions, that act as buffers in the transmission of body weight through muscle or other action

There are four main curves in the spinal column In the cervical region the curve has its convexity directed toward the front In the thoracic region the convexity is directed dorsad, and in the lumbar region the curve is directed toward the front as a convexity In the sacral region the curve is directed toward the front as a concavity, so that there is an alternating convex-concave arrangement, which gives greater elasticity in the transmission of body weight and at the same time, gives greater stability and support

Carey estimated that the normally curved spine is approximately sixteen times stronger than if it were one single straight line made up of the series of elements normally found The movements that are capable of being made in the spinal column are variable in different parts of the region The four main movements are ventral flexion, dorsal extension lateral flexion or abduction from the median line, and torsion around a vertical axis

The spinal column is approximately 71 cm in length in the male and about 61 cm in the female

The curves of the vertebral column, according to Carey, serve the following purposes (1) they contribute to the strength of the spine, (2) they

convert the spine into an elastic structure and thus afford a springy pillar upon which the head can rest, minimizing the danger of severe jarring of the brain, (3) the curves are so arranged as to favor the lodgment of organs, since the cavity of the chest is greatly enlarged thereby, and the

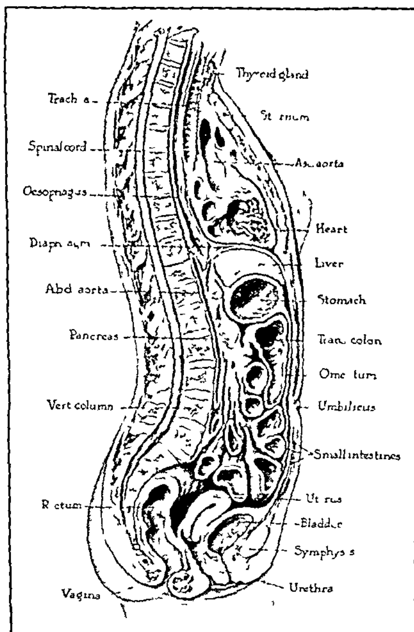


Fig 25 —Median sagittal section through trunk in the female (Courtesy of S H Camp and Co)

weight of these organs is kept within the limits of the muscle power required to preserve the proper balance (4) the curves are so gradual as to prevent the possibility of compression of the spinal cord which might occur were there any abrupt angles to the canal (5) the curves of the cervical and thoracic regions add to the beauty of outline of the body

Keller finds that the size and thickness of the intervertebral cartilages or disks are in close relationship to the amount and extent of mobility of the spine The thoracic vertebrae, with limited motion, have the smaller disks, while the cervical and the lumbar with their free mobility, have the larger The intervertebral disks act as shock absorbers or buffers and diminish the jarring of the vertebra produced in walking also prevent the jarring of the steps taken, from being transmitted to the head The latter function is further assisted by the natural spinal curves Any diminution of the size of the intervertebral cartilages will have an effect on the welfare of the body as a whole through its irritating effects on the nervous system Beneke points out that the vertebral column becomes shorter during the day and regains its normal length during the night

According to Carey the normal living anatomy of the spine as studied by the roentgenograph as well as by the physiological variations, chronological changes and anomalies of the spinal column, have a decided clinical importance These fundamental facts must be mastered if the roentgenologist and orthopedic surgeon are to avoid errors of diagnosis The lowest vertebra of this flexible weight-supporting spinal rod is based on the sacral or pelvic cushion the head is poised on the highest vertebra

The leverage and motor system of an individual vertebral segment is best seen in a vertebra taken from the thoracic region The posterior or spinous lever bifurcates at its root so as to enclose and protect the spinal cord, an elaborate system of muscles is attached to the spinous lever whereby the vertebral body may be maintained in its correct antero-posterior plane On each side of the vertebra is placed a lateral lever, rendered enormously powerful by being prolonged as a rib These lateral levers are also furnished with elaborate sets of balancing muscles

Muscle Physiology — There are two different muscle functions—that of postural tone and that of movement The former controlled by the autonomic system should maintain the correct position without effort or fatigue When it fails in its function the other function of voluntary muscular contraction may be called in to take over its duties This quickly leads to fatigue and pain With this fatigue there is an exaggeration of the normal curves The lumbar lordosis is increased and the intervertebral joints are maintained at the limit of their motion The strain is usually felt after a prolonged rest in bed A similar sequence of events is produced by regular employment which necessitates lifting or carrying heavy weights or assuming a flexed position As a result of the long strain in the fully flexed or extended position, the bones undergo a degree of moulding and the ligaments are stretched until eventually the muscles cannot correct the deformity Balance is upset and a gradual increase in deformity results

Flexion of the spine is produced by the contraction of muscles that are situated on both sides, in front of the spine rectus abdominis, external and internal obliques assisted by the sternohyoid, sternothyroid sterno-cleido-mastoid thyrohyoid, digastric scalenus anticus, longus colli and longus capitis In the lower part of the body, the direct flexors are assisted by the psoas and quadratus lumborum muscles

Extension of the spine is accomplished by the combined action of pairs of muscles situated posteriorly on both sides of the spinal column, the extensor muscles

The extensor muscles are erector spinæ, semispinalis multifidus spinæ, rotatores spinæ, interspinales, serrati posteriores, splenius and levator angulæ scapulæ and the upper fibers of the trapezius In the upright spine every one of these muscles (about eight to each vertebral segment) is called into action, by a static postural automatic reflex mechanism Any agent that upsets the normal dynamic equilibrium of the motor system of the back will be evident in the spinal indicator of muscle balance and imbalance The motor system of the back is maintained in normal balance by the integrity of the nerves muscles, tendons bones and joints These five anatomical factors form a physiological system of motion If the muscles on one side contract more powerfully than those on the other side lateral bending of the body or bending with rotation will occur The pelvis motivates the back rather than vice versa Saunders and Inman state that the center of gravity of the body is at the level of the second sacral segment

Baker found undernourishment in 25.2 per cent of school children This results in a dystrophy of muscle and bone growth Dissociation of muscular and skeletal growth is more evident in boys than in girls The focal muscular atrophy and paralysis of undernutrition will upset the muscle-bone balance of the normal spine and may be the insidious cause of idiopathic scoliosis and certain types of low-back pain The problem of scoliosis is a problem of prevention of all conditions that upset the normal balance of muscle and bone during growth This has been proved by Carey s work on experimental animals in the production and prevention of myogenic scoliosis Steindler has a similar point of view in preventing structural scoliosis by the elimination of those generalized debilitating conditions that he designates prescoliosis

Scoliosis is a sign of the imbalance of muscle and bone growth of the motor system of the back The kind and degree of scoliosis are dependent upon the extent of the imbalance, caused by the weakening of multiple combinations of the muscle groups of the body as a whole Accurate anatomical and physiological knowledge of the motor system of the back as a whole is necessary for an understanding of pathological changes in the spine

Bencke points out that the vertebral column becomes shorter during the day and then regains its normal length during the night So, not even the normal intervertebral disk is in possession of any absolute elasticity As the elasticity decreases the margins of the intervertebral disks project beyond the edges of the vertebral bodies especially as the load, the pressure is greatest at the periphery The cartilaginous disk becomes more flat and wider than normally

CHAPTER 5

ETIOLOGICAL FACTORS IN BACK DISTURBANCES

The causes of back disturbances include consideration of age, sex, congenital anomalies, developmental defects, postural abnormalities, mechanical strain, trauma, epiphysitis, infections, toxic factors, arthritis, gout, paralytic and functional neurogenic lesions, visceral lesions, muscular and fibrous tissue affections, metabolic, nutritional, endocrine, allergic, climatic, circulatory, neoplastic, gynecological, obstetrical and urological lesions.

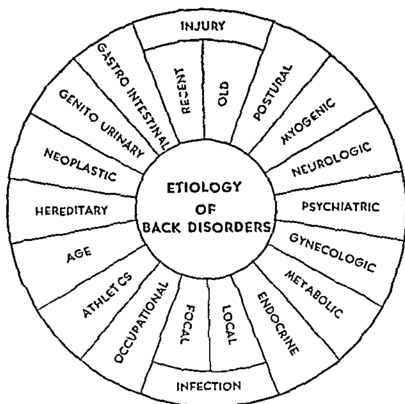


Fig. 26.

The etiologic factors involved in back disorders are numerous and varied. It was thought and in many circles anticipated that the recognition and establishment of the Disk Syndromes would simplify the problem.

GENERAL DISCUSSION OF THE CAUSES OF BACKACHE

Trauma is involved in practically every person who consults a physician, or every case that confronts a physician. It may be severe trauma, minor trauma, or insidious trauma.

A background of congenital anomalies such as a "weak" back or other factors of infection or metabolic disorder are usually discoverable if the examiner will take the time to inquire. Too often the examiner is in a hurry to examine the patient and is content to read someone's x-ray report.

General Discussion of the Causes of Sciatica.—The causes of sciatica are chiefly disk disorders, arthritis, mechanical disorders, trauma, infection, or metabolic disorders.

The Relation of Back Pain to Bed Posture.—This may be very important. As an isolated factor it is usually not important; as a contributing factor, it may be important; as a continuing force, it may be responsible for much trouble.

The Relation of Back Pain to Sleep and Sleeping Postures.—1. The production of pain may depend upon primary, secondary, or precipitating factors.

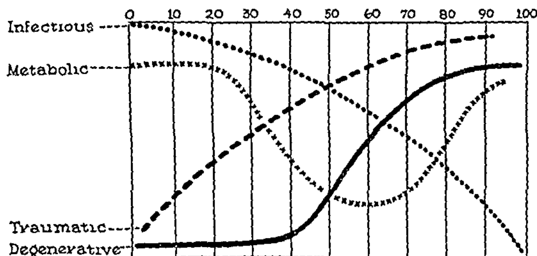


Fig. 27.—Curves showing the relative importance of four etiologic factors in back disorders in relation to age. (Lewin: The Knee.)

2. Relief may be obtained by sleeping in a supine position, sleeping in a prone position, sleeping in a lateral posture, or sleeping on a side with hips and knees flexed.

Many persons have less pain after a restless night than after a night *when they slept soundly and did not move much.* It may be a soft tissue reaction. The *mechanism* may be obliteration and return of normal spinal curves, recoil of compressed disks, stretch of the anterior and posterior spinal ligaments, stretching of the dura. This is aggravated if there are any adhesions, spinal muscles spasm producing tension, nerves stretched over osteophytes, or blood vessel changes.

Relation of Disorders of the Back to Those of the Foot and Ankle and the Knee.—*There is often a reciprocal between these structures. It is a mechanical chain reaction.*

DEGENERATIVE CHANGES IN THE SPINAL COLUMN

Coventry emphasizes the fact that as man evolved from the quadruped and assumed the orthograde position abnormal stresses and strains developed on his spinal column These stresses and strains plus the normal process of age, cause degeneration Degenerative changes are responsible for the majority of mankind's aches and pains

The lumbosacral region is affected by degenerative changes to a greater extent, and at an earlier age than the other regions of the spinal column The degenerative changes occurring in man's back start very early As soon as a child assumes a sitting position regression begins As aging occurs these changes increase Developmental changes occur before birth and continue until complete growth has been reached

THE CAUSES OF BACKACHE MAY BE

1 Congenital	8 Neurogenic
2 Developmental	9 Myogenic
3 Epiphyseal	10 Arthrogenic
4 Static postural	11 Fibrogenic
5 Traumatic	12 Neoplastic
6 Infectious	13 Psychogenic
7 Metabolic	14 Idiopathic

The main etiological factors of back disorders fall into six groups (1) injury (2) postural strain (3) congenital malformations (4) spinal diseases involving bones and joints, (5) extra-spondylar diseases and disorders and (6) tumors

A Composite Outline of the Causes of Back Disorders

Congenital Causes

- Defects in neural arch
- Variations in spinous processes
- Elongation of transverse processes
- Lumbarization of first sacral vertebra
- Sacralization of fifth lumbar vertebra
- Variation in lumbosacral angle
- Congenital spondylolysis
- Variation in articular facets

Traumatic Causes

- Severe single injury
- Multiple minimal injuries
- Injuries to vertebræ
  - Fracture
  - Dislocation
  - Fracture-dislocation
  - Post-traumatic epiphysitis or spondylitis
  - Injuries to intervertebral joints
  - Traumatic spondylosis
  - Traumatic spondylolisthesis

A Composite Outline of the Causes of Back Disorders—(*Continued*)

Traumatic Causes—(Continued)
- Injuries to intervertebral disks
  - Narrowing disks
  - Protrusion of disks
  - Rupture of nucleus pulposus
- Injuries to ligaments
  - Torn ligaments
  - Hypertrophied ligamentum flavum
- Injuries to fasciæ
  - Aponeurotic tears
- Injuries to muscle
  - Rupture
  - Hematoma
  - Adhesions
- Injuries to nerves
  - Compression
  - Laceration
  - Adhesions
  - Spinal concussion
- Foreign bodies embedded in tissues of back
  - War injuries

Mechanical Strains and Sprains
- Postural strain
- Occupational or athletic strain
- Lumbosacral sprain
- Sacro-iliac sprain
- Inequality of length of legs
- Static deformities of the feet
- Muscle palsies or paralyses
- Sequelæ of operations
- Sequelæ of prolonged immobilization

Infectious Causes
- Acute or chronic infections

Neoplastic Causes
- Primary or metastatic tumors of bone
- Benign or malignant chordoma
- Specific neoplasms
- Neoplasms of spinal cord and meninges
  - Cysts
  - Solid tumors

Metabolic, Endocrine and Degenerative Causes
- Rheumatoid arthritis
- Osteoarthritis
- Nutritional disturbances
- Rickets
- Paget's disease
- Gout
- Osteomalacia
- Hyperparathyroidism
- Hyperthyroidism
- Acromegaly

A COMPOSITE OUTLINE OF THE CAUSES OF BACK DISORDERS (*Continued*)

Metabolic, Endocrine and Degenerative Causes—(Continued)
- Osteoporosis with or without pathological fracture
- Obesity
- Leanness

Circulatory Causes
- Ischemic backache
- Hemorrhage and hematoma
- Calcification of aorta

Nervous System Causes
- *Infections of nervous system and meninges*
    - Neuritis
    - Radiculitis
    - Meningitis
    - Encephalitis
    - Arachnoiditis
    - Poliomyelitis
    - Brain abscess with meningitis
    - Herpes zoster
- Destructive lesions of nervous system
- Syringomyelia
    - Disseminated sclerosis
    - Amyotrophic lateral sclerosis
- Traumatic lesions of nervous system
    - Hemorrhage
    - Edema
- Psychosomatic causes
    - Hysteria
    - Camptocormia
    - Malingering

Hematological Causes

Thoracic Causes
- Fracture of ribs
- Pleural adhesions
- Pneumonia and empyema
- Tumors
- Aneurysms
- Sequelæ of rib resection or thoracoplasty

Abdominal Causes
- Visceral
    - Cholecystitis and cholelithiasis
    - Duodenal or gastric ulcer
    - Ulcerative colitis
    - Pancreatitis
    - Appendicitis
    - Neoplasms
- Retroperitoneal
    - Abscesses
    - Tumors
    - Aneurysm of abdominal aorta
    - Kidney lesions
        - Infections
        - Neoplasms
        - Stone (kidney or ureter)

A Composite Outline of the Causes of Back Disorders—(*Continued*)

Urological Causes

- Prostatitis
- Seminal vesiculitis
- Lesions of bladder
  - Cystitis
  - Neoplasms
  - Stone
- Lesions of ureter
  - Stone
  - Obstruction from other causes
- Lesions of kidney
  - Infections
  - Neoplasm
  - Stone
  - Torsion
  - Ptosis
  - Hydronephrosis

Gynecological Causes

- Mechanical
  - Prolapsed uterus or ovary
  - Retroversion and retroposition
  - Adhesions
- Inflammatory
  - Salpingitis
  - Endometritis
  - Endocervicitis
- Neoplastic
  - Benign
    - Fibromyomas
    - Endometriosis
    - Cysts of ovaries
  - Malignant
    - Carcinoma of uterus or ovaries

Obstetrical Causes

- Mechanical and postural
  - Before }
  - During } delivery
  - After }

There are many general and local conditions which will produce sciatic neuritis, although protrusion of an intervertebral disk is one of the commonest. O'Connell concluded that the most common cause of sciatica is root pressure from a protruded disk. Key believes that in almost all cases of idiopathic low-back pain with or without sciatica the symptoms are due to lesions of intervertebral disks in the lumbosacral region or to a traumatic neuritis of the nerve roots in this area. Ghormley and his colleagues made a statistical study of 2000 cases of backache encountered at the Mayo Clinic. The distribution of the group is given in Table 1.

TABLE 1.—GROUPING OF 2,000 CASES OF BACKACHE ACCORDING TO CAUSE
(Ghormley, Mayo Clinic)

Cause	Number	Per cent of 2,000 cases	Sciatic pain cases
Osteoarthritis	511	25.6	44
Protruded disk suspected	445	22.3	324
Indeterminate causes	384	19.2	24
Static disturbances present	160	8.0	3
Rheumatoid spondylitis	131	6.5	5
Coccygodynia	55	2.7	1
Previous trauma	52	2.6	4
Spondylolisthesis	44	2.2	9
Tuberculous spondylitis	38	1.9	2
Osteoporosis	36	1.8	1
Recent trauma other than fractures	31	1.6	0
Recent fractures	25	1.3	1
Spondylolysis	13	0.7	2
Scoliosis	11	0.6	0
Metastatic neoplasms of vertebrae	11	0.6	1
Fibrositis	8	0.4	0
Previous fusion operation	7	0.3	1
Primary neoplasms of cord and soft tissues	5	0.2	2
Gynecologic disease	5	0.2	1
Infectious spondylitis or osteomyelitis	5	0.2	1
Previous operation for disk with or without fusion	4	0.2	2
Facet syndrome	4	0.2	0
Primary neoplasms of vertebrae	3	0.1	0
Vertebral epiphysitis	3	0.1	0
Paget's disease	3	0.1	2
Interspinous ligament syndrome	2	0.1	1
Sacralization, partial	2	0.1	0
Metastatic neoplasms of cord and adjacent soft tissue	1	0.1	1
Compensation neurosis	1	0.1	0

The delicacy of the mechanism of the back cannot adequately be readily conceived. The automobile has one knee action, the back has many. The back has 23 intervertebral disks which act like bumpers, cushions or shock absorbers. Precision is a prerequisite to comfort and performance.

"Buckling" of the Back.—"Settling" of the back structures is similar to "Accordionization."

Causes:

- Poor posture
- Scoliosis
- Osteoporosis
- Malignancy
- Multiple myeloma

The structures that "settle" are:

- Disks
- Facets
- Ligaments
- Bones
- Muscles

The pathological changes produced in these structures are chiefly:

- Compression
- Friction
- Pinching
- Roughness
- Ischemia
- Neuritis
- Degeneration
- Necrosis
- Destruction
- Absorption

In spite of dogmatic statements to the contrary, there are still numerous and important causes of low-back and sciatic pain. I firmly believe that trauma is a *sine qua non*. The specific trauma might have been forgotten. The chief causes of severe trauma are those twisting injuries common to football, soccer or skiing, rather than to crushing injuries.

Degenerative arthritis of the spine may be present for a considerable period without causing pain, until the person suffers some trauma. This may be mild. It may be precipitated by bending over to wash one's face or getting up from a chair after watching television.

ANATOMICAL STRUCTURES INVOLVED

Ligaments do not withstand continuous strain as well as muscles do. According to Keith's Law, ligaments are never used for the continuous support of any joint or part. The primary cause of static deformities of the back lies in a defect or change in the bones, but the structures immediately responsible for the deformity are the muscles and ligaments around the joints.

R. H. Young reported a study of 957 patients operated on for back pain. Excluding 44 cases of spondylolisthesis, there were 913. He expressed the opinion that, in most instances, lame back and sciatic pain are due to lesions of intervertebral disks. He finds that nearly all other orthopedic causes of backache are revealed by the x-ray and those that are not are due to visceral lesions or neurosis.

OCCUPATIONAL FACTORS

Occupational stress and strain may be mild and often repeated or severe and occur infrequently. The summation of the former may eventually equal the effect of the latter.

TRAUMA

Trauma, or injury, may be acute or continued, mild or severe. Mild continued trauma affects the back of the housewife and mother. Severe continued trauma affects the iceman, the plumber and the piano mover. The continued use of a member in a poor mechanical position produces pain in the back.

Every movement of a joint causes trauma. If the trauma stops and if the circulation is good, the effects of the trauma are repaired almost immediately. If repair does not progress as rapidly as destruction, a pathological condition results. If circulation is impaired, the defect is not repaired and a lesion is formed. The balance between wear and repair is dependent on an adequate vascular response to function.

MICROTRAUMATIC CAUSES OF BACKACHE

The continued use of one's back in a poor mechanical posture produces pain. This may be called microtraumatic.

Phalen believes that the most common type of low back pain is the "mechanical backache" caused by some alteration in the normal body balance. This balance may be upset by faulty posture, obesity, relaxed abdominal musculature, weak back musculature and inequality of length of the lower extremities.

POSTURAL BACKACHE

Many people habitually assume positions of mechanical instability, and sooner or later under the stress and strain backache results.

A common cause of chronic low back strain is a sagging or protuberant abdomen which, by its weight and its downward and forward pull, tires the muscles and leads to increased tension on the ligaments supporting the lumbar portion of the spinal column. The postural backache of pregnancy may be explained on the same basis (with its exaggerated lumbar lordosis).

Static pain is brought on by use or physical activity and is relieved by rest. It is mechanical in origin. The cause may be post-traumatic in origin or it may be due to degenerative disease of the joints.

The manner in which a person gets out of bed may determine whether he will have an attack of backache or not. This is especially true if his sleeping posture was conducive or predisposed his back to the later strain of minor physical activity.

A surgeon told me that the worst backache he ever had in his fifty-five years of almost complete freedom from backache occurred when he attended a meeting of The American Academy of Orthopaedic Surgeons. He slept in a soft bed in one of the deluxe hotels and awakened with back-breaking pain. It was undoubtedly postural in origin.

I treated a lady who voluntarily slept on a pad on the floor while her husband slept in bed on a soft mattress.

EXTRA-SPONDYLAR BACKACHE

Backache is frequently due to non-spinal trouble. An experienced orthopedic surgeon can usually "spot" these cases from the history. He reports to the referring physician "Mrs. Jones has back trouble but not spine trouble." A common example of this situation is the presence of an Epi-Sacro-Iliac Lipoma body. Other examples are lumbago, myositis, ruptured muscle.

Backaches due to visceral lesions are very common. The orthopedic surgeon must be constantly on guard or he will fail to diagnose such conditions as duodenal ulcer, pancreas disorders including carcinoma, kidney and other urological structures, i.e., ureter-prostate, etc.

Gynecological disorders that cause or accompany backaches are described in subsequent chapters. Vascular and circulatory disorders may cause backache. Coronary artery disease in relation to spinal nerve pain is described elsewhere.

Fatty Tumors and Hematomas.—Fatty tumors and hematomas in the gluteal region often cause acute attacks of backache.

CONGENITAL CAUSES OF BACKACHE

In roentgenographic studies of the lumbar portion of the spinal column of 450 applicants for heavy work Breck, Hillsman and Basom reported that a total of 31 per cent presented evidence of some type of a congenital anomaly.

In an analysis of the causes of backache made at the Mayo Clinic, Young found that spondylolysis and spondylolisthesis as one large group were present in 2.9 per cent of the 2,000 cases, while partial sacralization of the last lumbar vertebra was present in only 0.1 per cent. Spina bifida, congenital scoliosis, wedge-shaped or supernumerary vertebrae and alteration in the plane of articular facets did not appear in this study.

Although congenital defects may result in weakness of the spinal column with impairment of ligamentous attachments or loss of bony anchorage, the defect may lie dormant until put to the test of stress, trauma or mere length of time of existence. Thus the pain due to congenital anomalies is rarely present before the second or third decade of life. Congenital anomalies *are important in laying the groundwork for subsequent mechanical trouble.*

Most persons who have congenital anomalies such as spina bifida occulta, sacralized L5 transverse processes, or spondylolisthesis never find it out until they are over forty years of age. It is usually brought to their attention by an injury or by a routine *x*-ray examination made for some other purpose.

SPINA BIFIDA OCCULTA

Spina bifida occulta of the fifth lumbar vertebra occurs in about 6 per cent of the population while the same defect in the first and second sacral segments occurs in 11 per cent. The neurologist, neurosurgeon, orthopedic surgeon and roentgenologist must collaborate in order to evaluate the importance of this anomaly. Walker found dilatation of the spinal canal and a lipoma in several cases of spina bifida occulta.

SPONDYLOLYSIS AND SPONDYLOLISTHESIS

The second most frequently observed congenital anomaly in Young's cases were spondylolysis and spondylolisthesis. Roche and Rowe studied the lumbar vertebrae of 4,200 skeletons and found spondylolysis was present in 4.2 per cent. The incidence of spondylolysis was almost constant between the ages of twenty and eighty years, indicating that the condition was usually present before the age of twenty.

SACRALIZATION OF THE LAST LUMBAR VERTEBRA

Brailsford found that 3.4 per cent of 3,000 patients studied roentgenographically had sacralization of the fifth lumbar vertebra on one side while 4.7 per cent had it bilaterally. In Young's series only 0.1 per cent of patients *complaining of back pain had this anomaly.* It is generally felt that complete sacralization of the last lumbar vertebra is not the cause of pain, but that partial sacralization may be

CONGENITAL SCOLIOSIS

Congenital scoliosis may be encountered in any portion of the spinal column. Through faulty ossification the body of a vertebra may become wedge-shaped or bifid, causing kyphosis or scoliosis. The status of such an anomaly may remain stationary or become progressive, and through faulty function of the spinal column osteoarthritic changes or encroachment on intervertebral foramina and pain eventually may develop.



FIG. 28.—A common cause of acute backache. An attempt to open a window that is stuck may cause sacro-iliac sprain, lumbosacral sprain, lumbago or protrusion of an intervertebral disk. (This strain mechanism is exaggerated if the person has to clear some large midline object like a radiator.) (Courtesy of R. H. Jackson, Am. J. Surg.)

BACKACHE OF GYNECOLOGIC ORIGIN

Backache is a common accompaniment of a primary or a secondary complaint in many gynecologic states. Backache in the presence of uterine prolapse is usually secondary to more prominent complaints of a bearing-down sensation in the pelvis or stress incontinence. Dysmenorrhea may be associated with acute backache.

Two conditions which commonly cause backache and are both associated with an acquired adherent retroversion of the uterus are extensive pelvic endometriosis and pelvic inflammatory disease.

Two types of backache closely related to pregnancy are (1) that caused by lordosis which has resulted because of the disturbed posture owing to the large anterior protrusion of the uterus during the last half of pregnancy, and (2) that found in women who are candidates for protruded intervertebral disks caused by aggravation and even protrusion of inter-

vertebral disks in the last half of gestation In some instances Hunt believes it is possible that the backaches attributed to coccygodynia or static disturbances may have been initiated at the time of a difficult delivery

Backache associated with pelvic malignant disease usually advanced carcinoma of the cervix may be severe and unremitting It is usually unilateral, arising in the region of the lumbosacral articulation or one hip and extending down the thigh and leg and possibly as far as the foot

BACK PAIN IN RELATION TO GASTRO INTESTINAL DISORDERS

Back pain is one of the manifestations of gastrointestinal disease can result from a summation of impulses originating in visceral walls and referred to the back along the sympathetic nerves which carry such impulses to the spinal cord

BACKACHE IN RELATION TO NUTRITIONAL DISORDERS

Rhodes believes that a great number of low backaches are nutritional problems Many of these lesions develop in the presence of an acid ash acidosis

SEATING FURNITURE

One approach to the correction of the mechanical backache is emphasized by Frivell It is a concept which attacks a major cause poor posture, and it has to do with improvement of seating or furniture design The majority of persons spend hours sitting each day and muscles cannot be expected to hold one all day long in the correct position If the chair is not correctly designed the body will sag as the muscles tire with consequent stresses and strains on muscles and ligaments of the spinal column Keegan s work should be consulted The common straight chair is too nearly vertical and pushes one forward into a round shouldered slump Oftentimes a chair is thought to be perfect immediately upon sitting but after a few minutes it encourages slumping

THE PRONATION SYNDROME

Laurence Jones described a syndrome in which primary pronation of the feet produces secondary internal rotation of the leg and a forward pelvic shift Multiple postural shifts cause deviations in weight bearing lines which result in the appearance of generalized fatigue dull leg aches low back pain of various patterns or sciatic neuritis

CHAPTER 6

SYMPTOMS OF BACK DISTURBANCES

PATIENT'S HISTORY OF HIS DISORDER

It is imperative to obtain a complete history before the physical examination is made The minimal groups of questions include pertinent facts concerning

I Family	V Arthritis
II Occupation	VI Metabolism
III Injuries	VII Neoplasms
IV Infections	

ROUTINE HISTORY-TAKING OF BACK DISTURBANCES

The various parts of the history are

1 Complaint
2 Duration
3 Cause
4 Progress
5 Treatment previously given, when, where, by whom and with what effect
6 The general health of the patient, which includes information concerning teeth, nose, sinuses, throat, gastro-intestinal and genito-urinary tracts, diet, infections, recent and old diseases and injuries
7 Concise specific statements are desirable

Many patients when giving their histories for the first time, fail to mention any past injury, however, when more closely questioned regarding accidents and injuries many of them recall some incident accompanied by backache which disappeared after a variable period and without special treatment Most of these persons had not connected their present complaint of backache or sciatic pain with the injury This is especially true if there has been a long period of freedom from pain

In all accidents involving the back, the surgeon should spend sufficient time in obtaining the history so that he may visualize the accident as though he were standing next to the patient when he was hurt

The following form when properly completed will furnish the minimum essential data

Date of accident Hour
Exactly where it occurred
Specific statements of accident
Effects of accident
What was done? (1) Where? (2) By whom? (3) Effect?
Subsequent events

THE HISTORY AS RELATED BY THE PATIENT

The history must be complete, minute and exact. A clear-cut history of events in chronological sequence is a most important part of the diagnosis. A thorough systematic review and analysis of the patient's history is the most important single aid in the evaluation of the causes of backache. Then from a knowledge of the:

1. Anatomical structures involved
2. Action of mechanical forces and the resultant of forces
3. Vulnerability of tissues
4. Symptoms
5. Clinical examination
6. X-ray studies

he can visualize the mechanical factors involved and he can integrate the components of the problem which are prerequisite to accurate diagnosis and appropriate treatment.

Then and only then can the examiner make an accurate diagnosis and an appraisal of the situation. Then, and not until then, can he prescribe or carry out proper treatment.

The examiner must be on guard for *exaggeration, dramatization, reticence, reluctance, evasion, falsification, vagueness and anatomically impossible statements*.

Some of the statements made by some patients are: "Pins and needles," "electric shock," "a dead feeling," "the pain shoots up to my brain," "Now I'll tell you, doctor," "I'm glad you are willing to listen," "It's a long story," "And now, doctor, I want you to tell me, did the previous doctors mistreat me?"

In getting the history, it helps to gain the confidence of the patient if the doctor will frequently use the patient's name. For example, "Now, Mrs. Jones, tell me exactly how the accident occurred." The sweetest music to many persons' ears is the sound of their own name.

It is important to ask: "Is this your first attack?" If it is not, what are the facts regarding previous attacks? *viz.*: cause, disability, treatment, result.

"Size Up Your Patient."—In the process of obtaining the history from some patients one should ask himself the question: Is he or she looking for sympathy or is he or she seeking confirmation of her complaints by the doctor?

When the examiner asks the question, "What do you think caused your trouble?" the answers will vary from "*What do I think? I don't think, I know!*" to "*I haven't the slightest idea!*" Is she withholding important information?

Many patients are "mildly belligerent" in relating their history.

Where legislation is pending, one should beware of being led into a medico-legal trap or at least into a difficult, unpleasant and unsolvable treatment problem. Some doctors will not undertake to treat certain persons until they either settle the legal controversy or drop the lawsuit.

Compensation may be a self-perpetuating mechanism producing invalidism. It may be responsible for the perpetuation of symptoms, often for unconscious purposes.

In many cases of any protracted alleged or genuine disability, the original organic disorder may be supplanted by an emotional aftermath used as an escape mechanism or for other purposes The examiners must refrain from making comments

A person may go to sleep unaware that anything is wrong or impending He awakens gets out of bed and starts for the bathroom On the third step he is seized with violent pain in his back and within a few minutes has severe sciatica He collapses to the floor and either screams with pain and lies on the floor or crawls back to bed and calls for help

If the patient has enough backache to enter it as a complaint, it deserves complete investigation It is essential that the examiner know certain basic facts By direct questioning early in the interview the patient should be asked

1 Whether the pain in the back followed injury or unusual physical exertion
2 The exact location of the pain is there any radiating pain?
3 Whether the pain is continuous or recurrent
4 What makes the pain worse
5 What relieves the pain
6 Whether the pain is getting worse
7 Whether a lawsuit is pending or anticipated

Frequent Statements Made by Patients, Some of Which Are Significant — One person will say "My pain has always been concentrated in a small area below my waist line, until the last two attacks Then I began to have severe pain shoot down my right leg

Another will say "I have always been able to sleep through the attacks except during the last two Then about two o clock every morning the pain forced me to get out of bed I would take a warm bath move around a little, sit in a chair and read a while Then I was able to go back to bed and sleep three more hours

These statements indicate mechanical pressure on the spinal nerves Formerly it was considered to be a characteristic story of a *spinal cord tumor*

Ninety-five per cent of these cases are due to *disk syndromes* and about 95 per cent of all disk syndromes involve disks below the fourth and fifth lumbar vertebra

POST INTERTIAL DYSKINESIA

Post-intertial dyskinesia is a term I coined to condense the sign or symptom related by many patients with back disturbances to the pain and stiffness felt upon resuming activity after a period of rest One has only to watch a group of people arise after a bridge game, a gin-rummy canasta or a poker game, or watch passengers get out of a bus after a long uninterrupted auto ride, to see a certain number of them move in a stiff, awkward position, often accompanied by pain

In some persons it disappears in a few seconds, in others it may last some minutes or even longer This is due, not to a bone condition primarily so much as to a periarticular disorder in the fibrous connective tissues around

a joint. That is, the muscles, the ligaments and the fasciae which have become shorter during rest, rebel when they are suddenly stretched, before they are warmed up or before sufficient circulation has been restored. It is a sort of "gelling" of tissues, which means the change from a liquid or semi-liquid state to a more rubbery or jelly like state.

The increase in back discomfort that occurs so commonly after a good night's sleep is an interesting condition which has not been satisfactorily explained. It may be due to the stretching of the spine during recumbency, or to the contraction of fibrous tissues which have been in one position for a long period. Blood pressure, local circulation, contraction or shortening of fibrous tissues and muscles and the capsules of the joints are doubtless involved in these changes of posture. The mattress and spring may be at fault.

SYMPTOMS

The most important symptoms of back disturbances are discomfort, deformity and disability. The pain may be local or referred. Fatigue is almost a constant symptom. Weakness is due to many factors including the pain.

Coughing, sneezing or straining at stool aggravate most types of backache.

CHAPTER 7

PHYSICAL EXAMINATION OF THE BACK

The nurse prepares all female patients for examination

The more clothes a patient has on, the more points in diagnosis are missed This is especially true of conditions of the lower back the upper thighs, and the pelvis There are many methods of draping a patient, using a cape, a sheet, or a surgical gown If a female patient wears a brassiere, panties and stockings, she can be properly examined

The outline for a **routine examination of the back** follows If this routine is carried through, little of importance will be overlooked, and if the interpretation of these observations is correct a diagnosis should be made in the majority of cases No back examination is complete without an examination of the feet, neck, pelvic organs and rectum

Asymmetry of the pelvis may be present The difference in levels of the gluteal creases is not entirely proportionate to the inequality in length of the legs because when poliomyelitis affects the muscles of one buttock, that part is much smaller throughout The dimple at the posterior-superior iliac spine is a better landmark The entire thigh and femur may be slightly smaller due to a neurotrophic disturbance The **rhomboid of Michaelis** is a diamond-shaped structure formed by the dimples at the posterior-superior spines of the ilia the lines formed by the gluteal muscles and the groove at the lower end of the spine Variations in its shape and size give valuable information If this rhomboid is outlined on the patient while standing the vertical axis should be parallel with the long axis of the body See Figure 2

The **physical signs** may include a peculiar gait due to the fact that the patient holds his back rigid Flexion of the leg with the knee extended furnishes certain definite evidence first, the limit to which the limbs can be flexed before muscle spasm is produced, second, the pain produced by this maneuver and its location

The most important consideration in making a complete physical examination is **routine** The examiner must make his observations in a natural sequence in order that he may accurately analyze, interpret, coordinate and integrate those observations Diagnostic signs are elicited or exaggerated by certain movements Any act that increases intraspinal pressure, such as coughing sneezing or straining at stool, causes or exaggerates nerve root pain The production of radicular pain following these three acts is called "Dejerine s triad '

Lewin's Snuff Test —During examinations for the cause and localization of backaches I have directed many patients to inhale a pinch of snuff to cause them to sneeze This often localizes the seat of the pain

The patient should be examined in the **standing, sitting** and **lying** positions

The **knee jerk** may be diminished or absent, and there may be hypesthesia and gluteal atrophy

The **Achilles jerk** may be absent or reduced in amplitude and strength

It is imperative that a thorough general examination be made. The patient must be stripped for examination of the back. A short gown, open in the back, may be used.

The examination of the back includes:

Inspection	Special tests
Palpation	Neurologic tests
Mensuration	Roentgenograms
Routine tests	Laboratory tests

The patient should always be examined in four positions: prone, supine, sitting and standing. A back examination consists of a series of simple but technical tests and maneuvers. Each has a name. Each has some diagnostic significance whether positive or negative. Some tests are compatible with certain conditions but are not necessarily proof that they are present. There are compatibles and incompatibles. There are tests that are confirmatory and others that are conformatory.

The examination must follow a routine or the results will mislead the physician. The physical examination must include the observation and recording the following items. The interpretation and significance of each in any particular case is another problem.

1. Limp
2. Spastic back
3. Straight back
4. Flat back
5. Sway back
6. Scoliosis
7. Pelvic imbalance
8. Inequality of leg length
9. Knock knees
10. Bow legs
11. Flat feet

BACK" EXAMINATION

1. Standing
2. Sitting on chair
3. Kneeling on chair for heel reflex
4. Sitting on table crosswise, legs dangling, for knee reflex
5. Sitting on table, full length, with legs outstretched
6. Lying supine on back for leg tests—Soto-Hall, Haldeman test
7. Lying prone on face and abdomen—trigger points, anatomical structures, Ely and other tests
8. Lying on left side (head north) left leg flexed—right leg extended
9. Lying on back at side edge of table (head north or east) left leg flexed—right leg extended
10. Turned around—lying on right side—right leg flexed—left leg extended
11. Lying on back at side edge of table (head south or west) right leg flexed—left leg extended
12. Neurological examination
13. Examination of feet
14. Examination of neck
15. Rectal examination
16. Vaginal examination

Mennell deserves great credit for his clear-cut instructive description and illustrations of a routine back examination These classical figures are a *sine qua non* to an adequate examination

Physical examination requires adequate exposure of the patient A lady is instructed to remove everything except her brassiere, shorts and stockings This is preferable to a sheet apron or gown A man is instructed to remove everything except his shorts and his hose

INSPECTION

Inspection begins as soon as the patient walks into the examining room One should observe how the patient walks how he sits down and how he takes off his shoes and hose The patient with a painful back moves guardedly

Observations to Be Made

1 Exaggerated lordosis
2 Pelvic balance
3 Muscle spasm
4 Flattening of the lumbar lordosis
5 Poker spine of ankylosing spondylitis
6 Prominent spinous process of the fifth lumbar vertebra
7 Angular kyphosis of Pott s disease
8 Rounded thoracic kyphosis of Scheuermann s lesion
9 Presence of atrophy of a calf

Movements of the Spinal Column —Range of movements of the spinal column is determined with the knees flexed and then held straight

PALPATION

Palpation and percussion over the spinous processes lumbosacral and sacroiliac joints should be carried out The degree of spasm of the paravertebral muscles is estimated One should ascertain whether or not there is tenderness on pressure over the sciatic notches or over the sciatic nerve itself The demonstration of palpable tender nodules is diagnostic of fibrositis or tumors

MENSURATION

Measurement of chest expansion is indicated when ankylosing spondylitis is suspected Measurement of the length of the legs may reveal a shortening which is affecting the spinal mechanics The calves should be measured at their greatest circumference and the thighs at two comparable levels

Pelvic balance should be determined while the patient is (1) Standing, (2) sitting (3) kneeling, (4) lying

NAME DATE

Examination of the Back

I Standing

INSPECTION

Posture Obesity
Anatomical location of affected area as referred to by patient (See diagram)
Type of respiration Thoracic Abdominal
Chest expansion in inches
Swellings Abscess Other masses

Areas of discoloration
Physiological anteroposterior curves
Round shoulders Dorsum rotundum Lordosis Sway back

Kyphosis Gibbus
Level of shoulders
Level of scapulae
Iliocostal angles
Level of iliac crests
Pelvic balance
Symmetry of buttocks Displacement or obliquity of interbuttock line
Level of gluteal creases
Dimples in regions of posterior superior iliac spines
Rhomboid of Michaelis
Atrophy—Back—Shoulders—Buttocks—Thighs—Legs—Feet—Hands

Feet— Front view Pronation Swelling
Back view Achilles tendon area Helbing sign

Gait— Coordination Romberg Test

Back Movements	Degree	Pain	Spasm	Area of Rigidity
Flexion				
Extension				
Lateral bend to R				
Lateral bend to L				
Torsion to R				
Torsion to L				

Squatting and flexing Back and Neck

II *Sitting on Chair*

Back Movements	Degree	Pain	Spasm
Flexion			
Extension			
Lateral bend to R			
Lateral bend to L			

III Sitting on Examining Table

With knees extended flexion of trunk attempting to touch toes
With knees flexed legs hanging over side of table
Which position more comfortable? Extension of spine *i e* exaggerated military attitude or flexion of spine *i e* round shoulder attitude
Smith Petersen Test Flexion of Back Lateral to Right
Extension of Back Lateral to Left

Neri bowing test

Examination of Feet while Sitting

Deformities Tender areas Corns
Injuries Metatarsal areas Calluses
Infection Heel region Ringworm

Examination of the Back—(*Continued*)

IV Lying Supine

	Right	Left
Length of legs		
Ant Sup iliac spine to Int Malleolus		
Umbilicus to Int Malleolus		

Degree of lumbar lordosis — Can it be obliterated?

Hip flexion with knee flexed — Active { Right / Left — Passive { Right / Left

Kernig Test R L

Hyperflexion of both thighs

Straight leg raising test — Goldthwait test — Lasegue's sign

	Free movement to what angle made by table and leg	When does muscle spasm appear? At what angle made by table and leg	Pain referred to
Right			
Left			

Fabere-Patrick Test
Right heel above left patella and dropping of right knee to table
Left heel above right patella and dropping of left knee to table
Lateral movements of both legs and pelvis
To right — To left
Hip rotation — Right — Left
Hip abduction — Right — Left
Laguerre Test
Soto-Hall Haldeman Test
Neri Test
Burns Bench Test

V Lying Prone

Active extension of spine
Approximation of heel to buttock—Ely Nachlas Test — Right / Left

Extension of thighs	Degree	Pain	Spasm
Right			
Left			

Palpation of back for abnormalities
Areas of tenderness to pressure—Trigger Points
Spine — Cervical — Thoracic — Lumbar
Sacro iliac — Right — Left
Sciatic nerve course knee flexed
Areas of sensitiveness to jarring and movements

VI Lying on Right Side

Ober test for hypertension of left tensor fasciæ latæ
Gaenslen test—hyperextension of one thigh with hyperflexion of the other
Right thigh hyperflexed and left thigh hyperextended
Pain referred to
Compression of iliac crests

VII Lying on Left Side

Ober test for hypertension of right tensor fasciæ latæ
Gaenslen Test—Left thigh hyperflexed and right thigh hyperextended
Pain referred to

Examination of the Back—(*Continued*)

VIII Minimal Neurological Examination

Reflexes	Knee	Achilles	Cremaster	Abdominal	Babinski
Right					
Left					

Areas of anesthesia (see diagram)
Areas of hyperesthesia
Naffziger-Spurling Test
Jugular Compression { By hand; By blood pressure cuff 40 mm

IX Rectal Examination

Male

- Hemorrhoids
- Prostate—size—consistency—secretion
- Coccyx—tenderness—mobility
- Coccygeus and piriformis muscles
- Sacro-iliac joint—tenderness or exudate

Female

- Hemorrhoids
- Coccyx
- Coccygeal and piriformis muscles
- Pelvic organs
- Sacro-iliac joints—tenderness or exudate

X Vaginal Examination

Discharge
Pelvic Organs Position Condition

XI Roentgenograms

Antero posterior projection
Lateral
Oblique
Stereoscopic
Laminagraph—Stratigraph
Roentgenograms of other joints

Scanography
Myelography
Nucleography
Dyskography

XII Special Tests

Laboratory tests
Lumbar puncture
Cerebrospinal fluid examination
Serology
Blood Examination
Urinalysis
Feces
Biopsy

XIII Summary

History
Physical Examination
Roentgen ray Examination

XIV Diagnosis

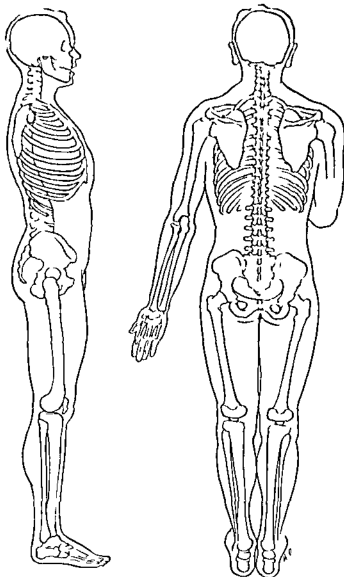
The lesion is
- Intervertebral
- Intravertebral
- Extravertebral

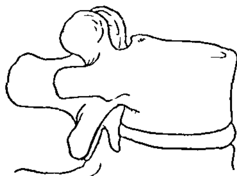
XV Recommendations

Office care
Home care
Hospital care Urgent Deferred
Support Day Night
Adhesive—Belt Corset—Brace
Physical Therapy Special Agents
Heat—Massage—Inductotherm
Pyrexia
Traction Head Pelvic Extremity
Injection intramuscular perineural intravenous

Examination of the Back—(*Continued*)

Manipulation		Under anesthesia	
Medication	For pain	Vitamins	For obesity
	For constipation	For constitutional defects	Other purposes
Diet			
Proteins		Fat	Carbohydrates
Additions		Restrictions	Proportions
Operation			
Fusion		Laminectomy	Others





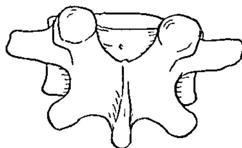


Fig 29 —Two views of a normal skeleton and a lumbar vertebra

DIAGNOSTIC PHYSICAL TESTS

Through common usage these tests have become known by proper names which is at present the most convenient way of identifying each. Some of the maneuvers are variations of others and elicit findings referable to the same pathological changes.

Tests Made with the Patient in Various Positions

Back, Pelvis, Hip and Leg Tests.—The most common of these tests are designated by the names of Kernig, Laguerre, Goldthwait, Campbell, Lasègue, Smith-Petersen, Gaenslen, Ober, Bechterew, Lindner, Neri, Lewin, Ely, Nachlas and Fabere-Patrick. The tests may be divided according to the positions the patient assumes while the maneuvers are made.

Standing. Flexion, extension, lateral bending, rotation, squatting, standing on each leg in succession, sniff test.

Sitting. Legs flexed, legs extended, Bechterew, Lindner and Neri signs.

Lying Supine. Goldthwait, Lasègue, Kernig, Smith-Petersen, Campbell, Speed, Gaenslen, Fabere-Patrick and Laguerre signs and buttock-punch test.

Lying Prone. Extension of back, extension of thighs, Ely and Nachlas signs.

Lying on Side. Compression of iliac crests, Ober test, Gaenslen-Lewin test.

Special Tests Made While Patient is Standing.—*Lewin Test.*—This test is performed while the patient is standing with his back to the examiner who very cautiously forces first the right and then the left knee into complete extension. Then both knees are straightened at the same time. In lumbosacral, lower lumbar, sacro-iliac and gluteal disturbances, these movements will be accompanied by pain and the knee will snap back into flexion. The test is helpful in localizing the lesion.

Neri's Bowing Test.—The patient, in a standing posture, is directed to bow. The sign is positive when he flexes his knee on the affected side as though he were curtseying, because the action causes pain in the leg.

Tests Made While Patient is Sitting.—*In a Chair.*—If a patient is relieved of backache when he sits, it means that relaxing the hamstrings gives him relief, indicating a pelvic rather than a lumbar localization of the lesion.

Bechterew first pointed out that a patient with sciatica is unable to extend both legs at one time while sitting, but can extend each in turn.

Sitting on the Examining Table.—This is the position in which one should examine the knee jerks.

Tests Made While the Patient is Supine.—*Goldthwait Test.*—The patient lies supine with both legs on the examining table. The extended leg on the side of which the patient primarily complained is flexed on the abdomen. Normally it should be possible to raise this limb to a right angle with the examining table before pain, muscle spasm or shifting of the pelvis occurs. The leg should be raised slowly with one hand under the lower part of the patient's spine. As the hamstrings tighten, leverage is

gradually applied to the side of the pelvis If pain is brought on before the lumbar spine begins to move, a lesion, either arthritis or a sprain of the ligaments involving the sacro-iliac joint, is probably present If pain does not come on until after the lumbar spine begins to move, the disease or injury may be in either the sacro-iliac or the lumbosacral articulations but is more likely to be lumbosacral The test should be repeated on the other leg If the lesion is lumbosacral, pain is felt when either leg is raised to approximately the same height, if the lesion is primarily sacro iliac, it is possible to raise the leg on the less involved side to a much higher level than the other, without pain

Laségue Test — This test is similar to the Goldthwait test The sign is positive when with the knee extended, flexion of the thigh is markedly limited or causes pain The Laségue contralateral sign is positive when raising the leg causes pain on the other side in the region of the tuber ischium, sometimes in the lumbar region and at other times down the entire leg

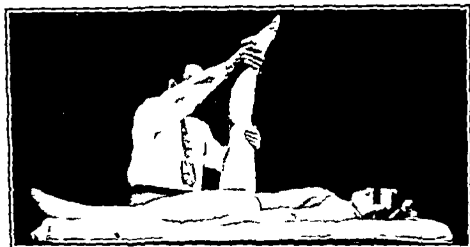


Fig 30 — Negative Laségue sign or normal straight leg raising (Manipulative Surgery Surgical Clinics of North America courtesy of W B Saunders Company)

While the patient lies supine the examiner places one hand under the patient s heel The other hand is placed on the knee With the limb extended, the examiner flexes the thigh on the pelvis Raising the limb only a few centimeters suffices to cause pain in the region of the sciatic notch at the point of the emergence of the nerve The patient feels severe pain and offers resistance when the thigh is flexed on the pelvis with the limb extended, but if one flexes the leg on the thigh he can flex the thigh on the pelvis without producing pain

To make certain that the pain is not due to sciatica the examiner lifts *the patient s leg while fixing the* pelvis on the same side by pressing heavily with his hand on the region of the homolateral antero-superior iliac crest The fixation of the pelvis prevents the stretching of the sacrolumbalis muscle but not of the sciatic nerve, and permits raising of the leg to an angle of 90 degrees without, or practically without lumbar pain unless it is due to sciatica The more acute the angle (formed by the leg and the

table) at which lumbar pain is first experienced, the more severe is the involvement of the sacrolumbar muscle. The test should be performed on both legs. The angle to which the legs can be raised without causing pain or spasm may vary as the pain may be more intense on one side.

Braggard's addition to the straight leg raising test is dorsiflexion of the foot, which increases the pain, supposedly an evidence of sciatica.

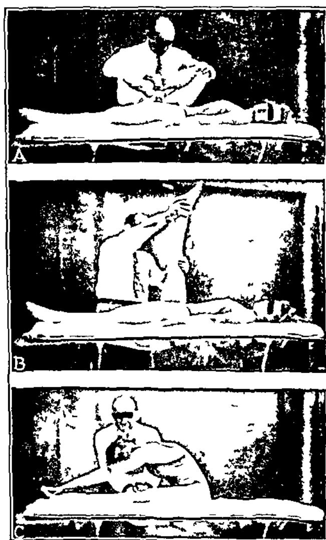


Fig. 31.—*A*, Normal flexion of hip and knee. *B*, negative Lasègue sign, negative Kernig. *C*, test for flexion of spine, touching toes with knees extended. (Lewin: Orthopedic Surgery for Nurses. Courtesy of W. B. Saunders Company.)

The Braggard test is made as follows:

Part I.—The patient lies supine on the examining table with his heels over the foot of the table for relaxation of the legs. The examiner places his right hand under the patient's right heel and his left hand just above the right patella. He then proceeds to raise the entire extremity off the table until he encounters pain or muscle spasm. This is the Lasègue straight leg raising test and can be described as being "positive at 30, 45,

or 90 degrees,² depending upon how far the test is carried before it produces muscle spasm, pain or a shift of the pelvis.

Part II.—When the limit of painless and spasmless movement has been reached, the examiner then forces the foot into strong dorsiflexion. This aggravates the pain or muscle spasm. This part of the maneuver is called the Braggard test.

The test has significance in cases of Disk lesions, sciatic neuritis, spinal nerve irritation and spinal cord tumors.

The straight leg raising is an important test. It is limited in cases of sciatica on the involved side. It is often limited on the uninvolved side. It is important to make certain whether any discomfort the patient may experience is a reproduction of the original back pain or sciatica. Discomfort may be due to stretching of the hamstring muscles or tendons or the posterior capsule of the knee joint.

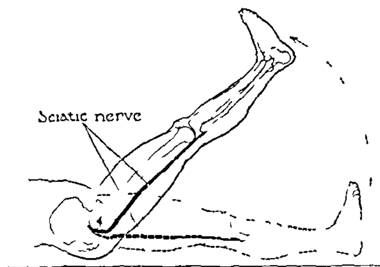


Fig. 32.—Illustrating the Lasègue sign. *A*, Right leg recumbent. *B*, straight leg raising, increasing tension on the sciatic nerve. A further modification of this test is known as Braggard test, which is performed as follows: when the Lasègue test is complete, the foot is dorsiflexed forcibly, which evidently enhances the value of the Lasègue sign. (Lewin, courtesy of Surg. Clin. North America.)

Lewin's Lasegue Test in Reverse.—*Lasegue Rebound Test. Drop Lasegue Test.*—Sudden dropping of the raised straight leg before it reaches its limit should be done last because it might cause an overflow of pain impulses.

At the exact point where the straight leg raising maneuver produces muscle resistance as recognized by the examiner or pain as indicated by the patient, the leg is suddenly allowed to drop, without warning, onto a pillow. This act aggravates the backache and sciatic pain and increases the degree of muscle spasm. It is analogous to the Ober test for the tensor fasciae latae syndrome.

Lewin Test.—For lumbar, lumbosacral and sacro-iliac arthritis, especially for the sciatic syndrome, I have found the following test of value. While the patient is lying supine with his legs in extension, the examiner places his arms or a strap transversely across the patient's thighs just above the

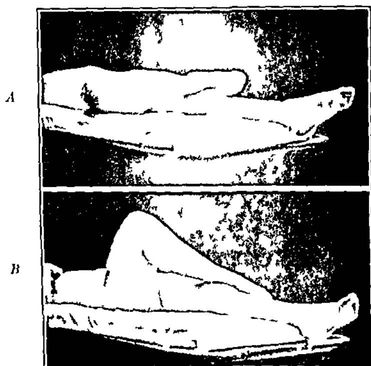


Fig 33 —Fabere or Patrick test for hip lesion *A* Normal *B* Knee "hung up" which is pathognomonic The so-called "sign of 4" (Lewin courtesy of Surg Clin North America)

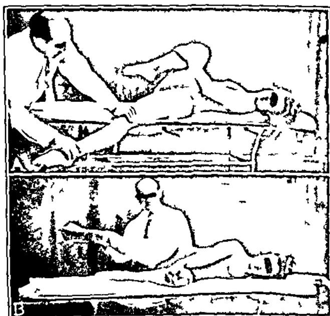


Fig 34 —*A* Gaenslen test with hyperflexion of the right side of the pelvis and hyperextension of the left *B* Lewin modification of position for making the Gaenslen test with hyperflexion of the left and hyperextension of the right sides of the pelvis Similar to the Ober test (Lewin's Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

knees. The patient is then instructed to sit up straight. With lumbar arthritis or sciatica he is unable to do so and indicates the area of his back made painful by the movement.

Lindner's sign is produced as follows. If enforced passive flexion of the head on the chest is effected with the patient in a recumbent or sitting posture with the leg outstretched, pain occurs in the lumbar region and in

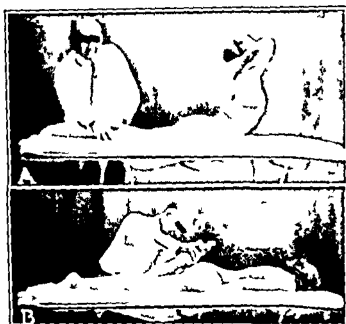


Fig. 35.—Patient lying prone on face. *A*, Active hyperextension of back. *B*, negative Ely test. Hyperflexion of knee with heel to buttock. In disease of the lumbar spine the whole area rises when the test is positive. (Lewin's Orthopedic Surgery for Nurses, courtesy of W. B. Saunders Company.)

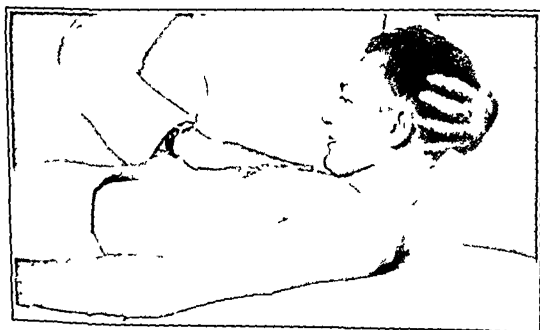


Fig. 36.—The Soto-Hall Sign. A diagnostic maneuver to detect vertebral injuries. (Soto-Hall and Haldeman, courtesy of Surgery, Gynecology and Obstetrics.)

the sciatic nerve distribution. Lindner said that this sign and the Lasègue contralateral sign are indications of root sciatica.

Soto-Hall described a maneuver which is helpful in the diagnosis of vertebral injuries. The patient is placed flat on his back without pillows, the examiner places one hand on the sternum of the patient, exerting a slight pressure, so that no flexion can take place at either the lumbar or the thoracic regions of the spine. At the same time the examiner's other hand is placed under the occiput and with this hand the head is bent upon the neck. Then, slowly but forcibly, the head and neck are flexed on the sternum. This produces a progressive pull on the posterior spinous ligaments starting at the ligamentum nuchae above and is transmitted downward to the interspinous ligaments until it reaches the spinous process of the injured vertebra. On this it acts as a lever, gently compressing the body and producing pain which the patient localizes accurately.

This test is slightly different from Neri's nodding test, which is indicative of radiculitis due to vertebral arthritis.

Smith-Petersen Test.—Motion away from the affected side is usually freer than motion toward that side. In the presence of acute inflammation, motion is more limited toward the side affected than away from it. In sacro-iliac strain the opposite is true. In doing straight leg raising slowly, one hand should be under the lower part of the patient's spine. As the hamstrings tighten leverage is gradually applied to the affected side of the pelvis. If pain is brought on before the lumbar spine begins to move, Smith Petersen considers that a sacro-iliac condition is present. If however pain does not come on until after the lumbar spine begins to move either sacro iliac or lumbosacral disease may be present because the sacro-iliac joint is under leverage and the lumbar spine is moving. The leg on the side opposite the one in which there is pain can be brought to a higher level than the other without pain. In lumbosacral conditions pain comes on when both legs are brought to the same level.

Fabere-Patrick Test.—With the patient supine the thigh and knee are flexed and one external malleolus is placed over the opposite patella the knee is depressed and if pain is produced thereby, a lesion in or around the hip is indicated. Patrick called this the "Fabere sign," from the initial letters of the movements necessary to elicit it flexion, abduction external rotation extension. It is also called the "sign of 4" test.

Laguerre's Test is carried out as follows. The patient lies on his back the thigh and knee are flexed and the thigh is abducted and rotated outward. This forces the head of the femur against the anterior portion of the capsule of the hip joint and produces pain. A positive test is indicative of a lesion of the hip joint, iliopsoas muscle spasm or a sacro-iliac lesion as distinguished from a lumbosacral lesion.

Gaenslen Test.—Gaenslen described a diagnostic maneuver which has proved valuable in the differentiation between sacro-iliac and lumbosacral lesions and between right and left-sided lesions. The patient lying supine flexes the knee and hip of the same side acutely the thigh being crowded against the abdomen with the aid of both the patient's hands clasped about the flexed knee. This brings the lumbar spine firmly in contact with the table and fixes both the pelvis and the lumbar spine. The patient is then

brought well to the side of the table, and the opposite thigh is slowly hyperextended by the examiner, with gradually increasing force by pressure of one hand on the top of the knee With the opposite hand, by pressure over the patient's clasped hands, the examiner assists the patient in fixing the lumbar spine and pelvis The hyperextension of the hip exerts a rotating force on the corresponding half of the pelvis in the sagittal plane through the transverse axis of the sacro-iliac joint The pull is made on the ilium through the Y-ligament and the muscles attached to the anterior-superior and inferior spines As a result of the impaired ligamentous support on

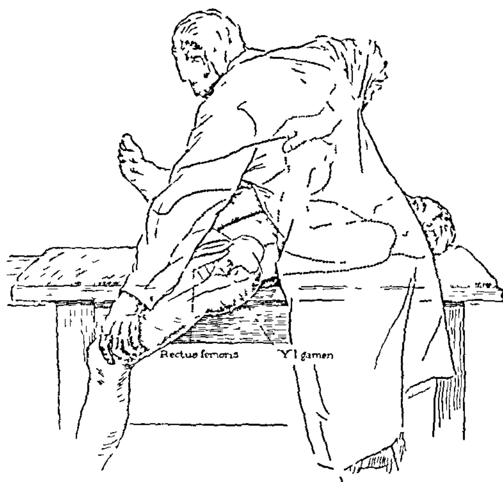


FIG 37 — Diagnostic maneuver helpful in differentiating between sacro iliac and lumbo sacral lesions The sketch shows forcible *hyperextension of left hip* with pelvis and lumbar spine fixed by means of extreme flexion of the right hip Pain generally present in sacro iliac is absent in lumbosacral lesions (Gaenslen *courtesy of Jour Amer Med Assn*)

the diseased side this rotating force causes abnormal mobility accompanied by pain, either local or referred, on the side of the lesion If the left hip is hyperextended and the lesion is in the left sacro-iliac joint the strain will be on the ligaments of this joint and the pain will be found at the joint locally or referred down the thigh If, on the other hand, the left sacro-iliac joint is unimpaired and the lesion is on the right side, the sacrum as a whole moves with the left side of the pelvis and the strain will be felt on the right side the pain in this instance being located at the site of the right sacro-iliac joint or referred down the right thigh

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the diseased side, this rotating force causes abnormal mobility accompanied by pain, either local or referred, on the side of the lesion If the left hip is hyperextended and the lesion is in the left sacro-iliac joint the strain will be on the ligaments of this joint and the pain will be found at the joint locally or referred down the thigh If on the other hand the left sacro-iliac joint is unimpaired and the lesion is on the right side, the sacrum as a whole moves with the left side of the pelvis and the strain will be felt on the right side, the pain in this instance being located at the site of the right sacro-iliac joint or referred down the right thigh

Lewin-Gaenslen Test.—I have modified Gaenslen's test by having the patient lie on one side, flexing the thigh and knee of that side with his hands and holding the knee flexed as completely as possible Then I manipulate the limb above with knee extended, producing hyperextension The patient then holds the upper leg while the under one is extended This does not necessitate moving the patient from one end or side of the table to the other

Compression of Iliac Crests.—With the patient turned on his side the examiner presses on the uppermost iliac crest so as to compress the pelvis from side to side

Tests Made While Patient is Prone.—Hyperextension of the patient s back without the aid of his hands may help to localize a spinal lesion by producing pain or muscle spasm

Ely's Heel-to-buttock Test.—In performing the Ely test, the patient lies on his face on the examining table with his toes hanging over the edge of the table for relaxation of the legs The right heel is approximated to the right buttock After flexing the knee, the entire thigh is hyperextended That is the Ely test If there is any lesion of the hip, it will be impossible to carry out this test normally If there is any irritation of the psoas muscle or its sheath, the test will be positive *viz* it will be impossible to get the thigh off the table to a normal degree Recently, O Connell applied this test in search of disorders involving the 3d lumbar disk or the 3d lumbar nerve In the presence of traumatic and inflammatory lesions of the spine, if the prone-lying patient s heel is forced to touch his buttock the pelvis or lumbar spine will rise from the table A positive Ely sign is an indication of a lumbosacral lesion Ober expressed the belief that Ely s sign indicates a contracture of the fascia lata

Nachlas Knee-flexion Test for a lesion in the lumbosacral and sacro-iliac joints This test was advised by Nachlas because it is simple and because by its remote control it avoids the confusion that attends direct manipulations of structures near the affected area

In this test the patient lies relaxed in a prone position on a rigid examining table, and the examiner flexes the knee by raising the foot up from the table When the test is positive, the patient experiences pain in the sacro-iliac or lumbosacral region and at times along the nerves that run in front of these joints The radiating pain follows the course either of the sciatic nerve along the back of the limb to the calf or the external cutaneous nerve on the outer side of the thigh to the knee If the patient has no skeletal abnormality in the lower part of the back he will experience no pain or only a feeling of tension in the front of the thigh

The requirements are (1) the table should be flat and non-yielding (2) the patient should lie prone and relaxed with the limbs side by side and (3) the leg should be passively raised directly up to flex at the knee It is occasionally desirable to rest a hand lightly on the back to keep the patient from buckling at the hips

The principle of this test is simple When the knee joint is flexed the patella and the rectus femoris muscle which is attached to it are pulled distally The long head of the rectus femoris is attached to the anterior-inferior iliac spine about 2 inches in front of the center of rotation of the

innominate bone on the femur Consequently, flexion of the knee tends to rotate the ilium forward and downward This torsional force manifests itself as a strain on the nearest sacro-iliac joint When this joint is intact, the sacrum is carried with the ilium, so that strain is applied either to the lumbosacral or to the opposite sacro-iliac joint The strain on a diseased joint causes pain in the joint itself, but the displacement produced, if enough to cause pressure on the adjacent nerve trunks, is often recognized by pain referred to the skin-sensory areas of the affected nerve

A positive reaction is an indication that disease is present in the lower part of the back and when the response is felt in a specific joint it is safe to assume that joint is the affected one On the other hand one cannot differentiate trauma from arthritic affection A negative reaction does not rule out skeletal disease

Lewin Test —In a case of fixed external rotation of the leg the heel approaches the opposite buttock

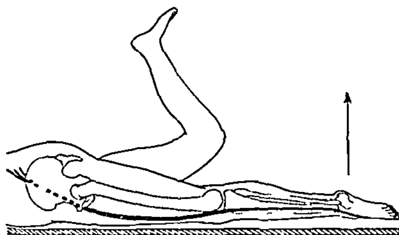


FIG 38 —Representation of the femoral nerve stretch test which is helpful in the diagnosis of upper lumbar disk protrusions (O Connell)

Mennell's Test —In eliciting Mennell's sign an examining thumb is placed over the postero-superior spine of the sacrum and then made to slide, first outward, then inward If pressure over the outer point shows tenderness, it is due to a sensitive deposit in the structures of the gluteal aspect of the postero-superior spine If the tenderness is over the inner point, it is probable that the superior ligaments of the sacro-iliac joints are strained and sensitive When the tenderness is increased by pressure backward on the antero-superior aspect of the ilium and decreased by pulling the crest forward from behind, this is indicative of a sensitive ligament

Tests Made While Patient is on His Side —Compression of the iliac crests should be carried out with the patient lying on his side The examiner puts his forearm on the affected side and leans on it, giving sustained pressure sometimes for as long as one-half minute If the reaction is positive, there is likely to be acute inflammation or severe strain, if it is negative, however it does not rule out a sacro-iliac lesion

The Ober Test —Ober discovered that the iliotibial band is an important factor in the occurrence of lame back, with or without an associated sciatica

The method of eliciting the abduction sign The patient lies on his side, with the thigh next to the table flexed enough to obliterate any lumbar lordosis The upper leg is flexed at a right angle at the knee The examiner grasps the ankle lightly with one hand and steadies the patient's hip with the other The upper leg is abducted widely and extended so that the thigh is in line with the body If there is any abduction contracture the leg will remain more or less passively abducted depending on the shortening of the iliotibial band This band can be easily felt with the examining fingers between the crest of the ilium and the anterior aspect of the trochanter In some cases the pain on one side can be increased by doing the abduction test on the opposite side The pain will be increased in these cases also if the patient is asked to stretch his tight iliotibial band on the affected side while standing and leaning the hip toward a table keeping his body upright

This sign is present both in the conscious and in the anesthetized patient *If there is no contracture present the thigh will abduct beyond the median line*

Punch Test — Punching the buttock produces a referred pain in the back like a reversed Queckenstedt test

Rectal examination may reveal *important information In women it* may disclose disturbances of the coccyx and the lower portions of the sacro iliac joints One seeks information with regard to deviations from the normal anatomical positions evidence of exudate and tenderness to *pressure In men rectal examination supplies information concerning the* coccyx the lower portions of the sacro iliac joints and the size consistency, tenderness and secretion of the prostate and seminal vesicles The presence of anorectal disease or neoplasm should be ascertained

Vaginal examination *reveals information concerning the promontory* of the sacrum and evidences of the exudate and tenderness in the region of the sacro-iliac joints as well as lesions of the pelvic organs

NEUROLOGIC TESTS

In the examination of every patient a neurologic examination is imperative This includes testing the knee and ankle jerks Any area of *disturbed sensation is noted Any atrophy of a calf is observed Testing* reflexes should be routine If the doctor has a percussion hammer *on the desk of every* examining room in his office he will be reminded to use it

A MINIMAL NEUROLOGICAL EXAMINATION

Every physician should be able to make a neurological examination The equipment is simple a percussion hammer a pin a wisp of cotton a fountain pen or skin-marking pencil to outline skin areas a test tube with hot water another with ice water and a tuning fork

I have divided the subject into the following sections

I Station
II Attitude
III Ataxia

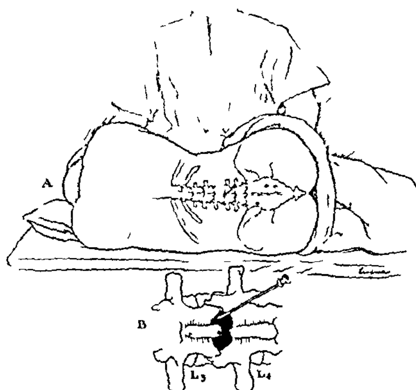


FIG 39 —Lumbar spinal puncture A Patient in side lying position for lumbar puncture knees flexed on abdomen back flexed head forward B relation of spinal needle in third lumbar interspace (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

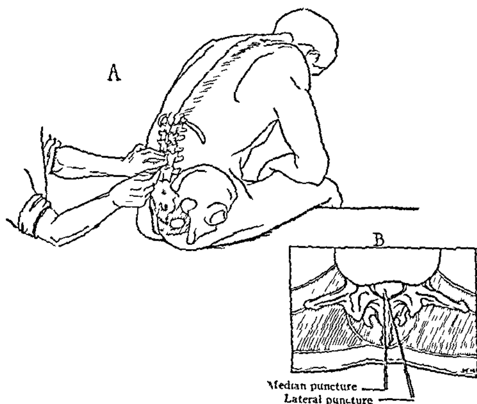


FIG 40 Technic of lumbar puncture A The left forefinger locates the area between the fourth and fifth lumbar spinous processes B is a cross section at this level to show the median and lateral insertion of the needle into the subarachnoid space (Callander Surgical Anatomy courtesy of W B Saunders Company)

IV Gait
V Coordination
VI Motor Power—Strength—Range of movement
VII Reflex activity
VIII Sensation—Sensorium—Tuning Fork
IX Trophic changes
X Local defects and lesions
XI Special clinical and laboratory tests
XII Spinal puncture is performed only in selected cases

The examiner determines first whether the patient can voluntarily put his feet in dorsiflexion, plantar flexion, pronation and supination, secondly, whether these movements can be made passively, thirdly whether they can be made against resistance fourthly, whether the patient can feel

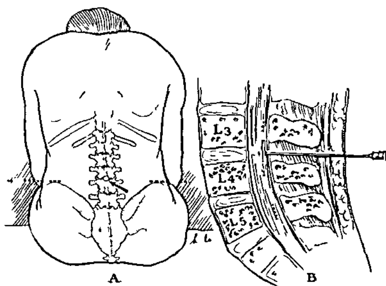


FIG 41 —Lumbar spinal puncture translated into sitting position for illustration only This position is prohibited in cases of suspected poliomyelitis *A* Sitting position back flexed head flexed arms forward arrow indicates third lumbar interspace *B* spinal needle *in situ* in third lumbar interspace (Lewin's Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

the touch of the hand on all areas of the skin, and whether he can differentiate between the sharp and dull ends of a pin between the sensation of a wisp of cotton and the stroking of a finger and between heat and cold applied by means of test tubes containing cold and warm water The presence or absence of the Babinski reflex is determined by stroking the sole of the foot along the outer border The proprioceptive sense is determined by moving the toes up and down and sidewise Ataxia can be easily demonstrated

A sharp fine caliber short bevel needle is required and extremely careful technic is imperative

Backache Following Lumbar Puncture —During World War I saw many patients with backache following lumbar puncture Patterson attributed the manifestation to a certain neurotic element and in many cases to pure neurosis Every patient could tell exactly how many punctures

he has had I disagree with Patterson, because in several cases I have seen postpuncture chronic backache was associated with diminution of the intervertebral space corresponding with the puncture I call it a "non-stop" spinal puncture Billington reported on the injury to bone and soft tissues

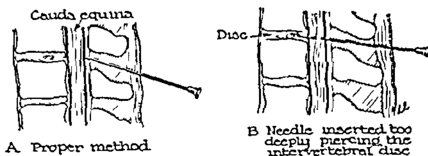


Fig 42 —*A* Proper position of needle in spinal puncture *B* non stop spinal puncture a cause of low backache (Lewin s Infantile Paralysis courtesy of W B Saunders Company)

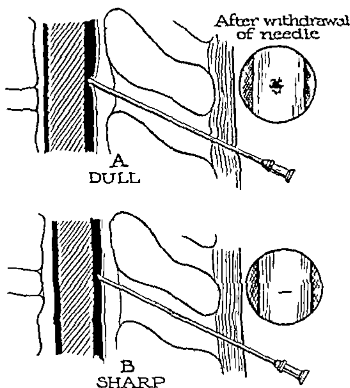


Fig 43 —Effect of dull needle in spinal puncture *A* Dull needle Insert shows jagged rent in dura after withdrawal of needle *B* Sharp needle Insert shows small slit which readily closes after withdrawal of needle (Lewin Infantile Paralysis courtesy of W B Saunders Company)

(as well as infection) from improper spinal puncture Pease described the syndrome of postpuncture disk collapse

Beevor s Umbilical Sign —The Beevor sign or test is observed as follows with the patient lying on his back, the position of the umbilicus is noted The patient is instructed to raise his head If there is an imbalance in power of the abdominal muscles the umbilicus moves, depending upon the

relative strength of the surrounding muscles The most common excursion is upward or cephalad in cases of weakness or paralysis of the lower abdominal muscles A deviation to the right indicates weakness of the left abdominal muscles The significance of this phenomenon is chiefly neurological It indicates a lesion in the region of the 8th to 10th thoracic spinal segments (7th thoracic vertebra) especially disease or injury of the spinal cord, a spinal cord or vertebral tumor, anterior poliomyelitis, transverse myelitis intervertebral disk injuries compression fractures or multiple sclerosis

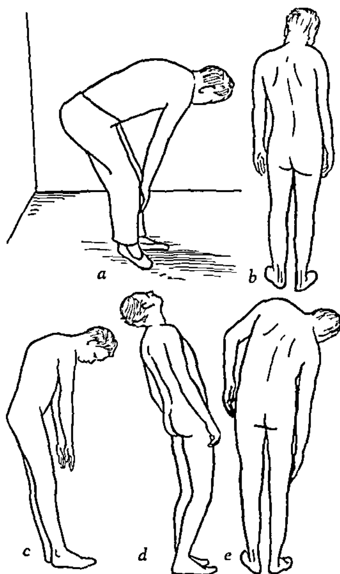


FIG 44 —Inspection of the patient with low back pain (James courtesy of Proc Mayo Clinic)

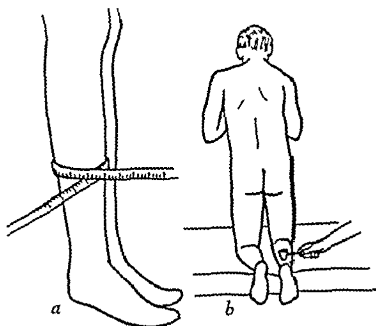


Fig 45 — A Measurement of the calf of the leg at its greatest circumference B Testing the ankle jerk (James courtesy of Proc Mayo Clinic)

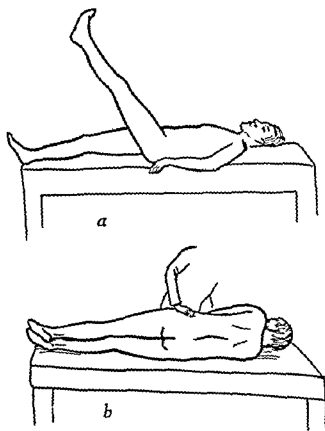


Fig 46 —*A* Straight leg raising test *B* Compression of the iliac crests (James courtesy of Proc Mayo Clinic)

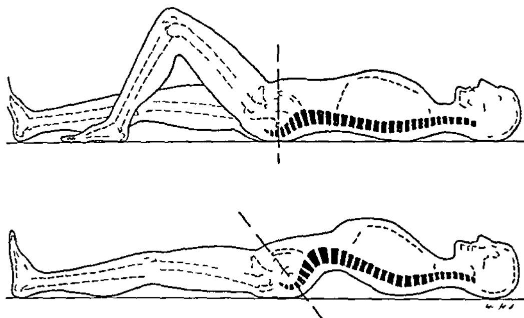


Fig 47 —Diagrammatic representation of the mechanics of the back pelvis and leg in *flexion deformity of left hip* *A* In order to place the lumbar spine on the examining table the left leg must assume the position of flexion *B* If the left leg is forced into the extended position the lumbar lordosis becomes strikingly exaggerated



Fig 48

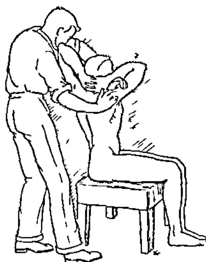


Fig 49

Fig 48 —Assisted hyperextension of lumbar spine in sitting position (Ellis The Injured Back and Its Treatment courtesy of Charles C Thomas)

Fig 49 —Passive rotation of lumbar spine on the pelvis in upright position Locking of arms prevents movement of scapulae on thoracic cage (Ellis The Injured Back and Its Treatment courtesy of Charles C Thomas)

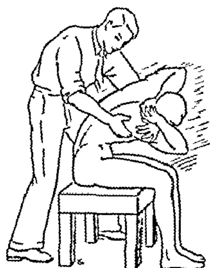


Fig. 50

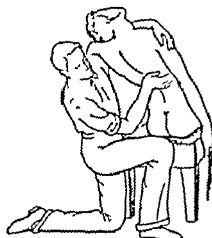


Fig. 51

Fig. 50.—In passive rotation with spine flexed force is exerted over the nearthrosis between a transverse process and the ilium in a sacralized L-5 and pain should be greater than in rotation as in Figure 49. (Illus. The Injured Back and Its Treatment, courtesy of Charles C Thomas.)

Fig. 51.—Rotation in the hyperextended position applies more force on the lumbosacral zygapophyses and aggravates a posterior disk prolapse. (Illus. The Injured Back and Its Treatment, courtesy of Charles C Thomas.)

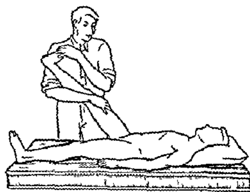


Fig. 52.—*Bragard's complement of Lasègue's test.* Extension at the ankle joint stretches the sciatic nerve. No exaggeration of sacro-iliac pain is expected by this maneuver. (Illus. The Injured Back and Its Treatment, courtesy of Charles C Thomas.)

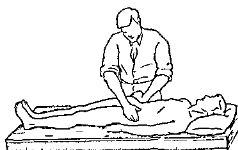



Fig 53 Fig 54

Figs 53 and 54 —Compression and distraction force stretches the posterior and anterior sacro-iliac ligaments respectively These tests are generally negative except in advanced sacro-iliac pathology because they do not reproduce the rotation strain which commonly produces sacro-iliac soreness (Ellis The Injured Back and Its Treatment courtesy of Charles C Thomas)

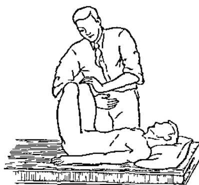
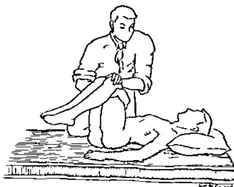



Fig 55 Fig 56

Figs 55 and 56 —Tests for localization of lumbosacral soreness and extent of spasm or contracture in sciatic scoliosis In acute injury of a sacro iliac joint compressive force is not so painful as distraction or separation of the affected joint (Ellis The Injured Back and Its Treatment courtesy of Charles C Thomas)

CHAPTER X

ROENTGEN-RAY FINDINGS IN BACK DISORDERS

This chapter includes basic considerations rather than specific descriptions. It contains discussions upon:

I Technic
II Pitfalls
III Basic normal findings
IV Basic variations from the normal
V General principles of roentgen interpretation and their significance

Roentgenography is helpful for diagnosis, prognosis and treatment. The roentgenogram is of the greatest aid in diagnosing and studying bone and joint defects, lesions, deformities, diseases, injuries and tumors of the vertebrae.

Radiology occupies an important position in teaching undergraduate medical students. Its diagnostic, prognostic and therapeutic applications have grown rapidly. *The student should be instructed in the appearance of normal spinal structures as visualized by the roentgen-ray and what abnormalities mean. He should be taught, however, not to become too dependent upon roentgenologic aid, to the exclusion of other diagnostic methods.*

One must remember that a roentgenogram is a shadowgram. It reveals the locations, relations and shapes of various anatomical structures and their *mechanical and pathological changes which are often worse than the roentgenogram indicates.* Age of bone is indicated by whiteness in the roentgen negative. Bone "scars" (or sclerosis) are revealed in white in the negative; they may indicate ageing of tissues or reactions to stress and strain. Pathological changes may cause the bone to resemble "sponge-candy," a paper-shell or curbstone.

The roentgen-ray has served to bring about a more common ground for discussion of back lesions between patient, public, attorneys, industrial military and orthopedic surgeons.

Roentgenologic examination of the vertebral canal is one of the important parts of the general survey. No examination of the back is complete without antero-posterior and lateral roentgenograms of diagnostic quality. A lateral roentgenogram of the lumbosacral joint is necessary when a lesion at this site is suspected. Oblique views are useful when one suspects lesions of the articular facets or neural arches. Stereoscopic antero-posterior roentgenograms of the pelvis supply valuable information.

BASIC ROENTGENOGRAPHIC CHANGES AND ROENTGEN-RAY INTERPRETATION

The basic changes and roentgen-ray interpretation include I Destructive, II Productive, III Absorptive, IV Condensing changes, V Displacements

The causative factor in the production of these changes may be I Congenital, II Developmental III Infectious, IV Traumatic, V Neoplastic, VI Metabolic, and VII Circulatory

Basic Roentgenographic Changes in Vertebræ

Changes in { Position—Location, Density, Shape, Structure }

Atrophy
Hypertrophy
Sclerosis
Necrosis
Destruction
Absorption
Calcification in soft tissues
Ossification of soft tissues

Roentgenographic Changes in Various Parts of Each Vertebra

Alignment
Size
Shape
Parallelism of vertebral borders
Size of intervertebral disks
Shape of intervertebral disks
Density of intervertebral disks
Vertebral Body
Pedicle
Spinous process
Transverse processes
Foramina
Facets

Fundamental bone and joint changes demonstrable by roentgenograms of the vertebræ are changes in density, shape and position of the parts

1 Changes in density include atrophy hypertrophy sclerosis necrosis destruction absorption calcification and ossification of such structures as the nucleus pulposus, cartilages muscle fascia and blood vessels One should contrast the densities of contiguous bones

2 Changes in shape include changes in contour and the presence of exostoses

3 Changes in position of the parts include fracture dislocation, narrowing of joint space widening of joint space and rotation

Fundamental vertebral bone structures to be studied are cortex intervertebral space articular facet, epiphysis, body, pedicle and intervertebral disk Lesions cast shadows which are constructive in osteomyelitis and syphilis, and destructive in tuberculosis and malignant diseases Bone tumors which are constructive, are usually benign, bone tumors in which destructive changes predominate are often malignant

'Pencilling' of vertebral borders is characteristic of atrophic arthritis osteomalacia and parathyroidism Effacement of cortical outlines is characteristic of injury tuberculosis, osteomyelitis and malignancy

Bone reactions should not be considered as diagnoses

Osteoporosis means an abnormal porosity of bone In osteoporosis the bone changes may be compared with "a change from curbstone to sponge-candy "

Decalcification means the removal of calcium salts from tissues It is shown in the roentgenogram by increased radiability producing darker areas in the negative

Rarefaction means the state of being less dense, *i e*, diminution in density and weight but not in volume

Halisteresis means a loss or lack of lime salts in bone

Bone atrophy means absorption of calcium salts with diminution in the amount of bone

Hypertrophy means increase in size of bone

Osteolysis means absorption or necrosis of bone The osteolytic processes include infectious, traumatic glandular and neoplastic lesions

Osteoclasis means a process of destruction of bone Osteoclastic processes are infectious traumatic, endocrine or neoplastic

Osteoblastic means building up of bone

Necrosis means the death of a circumscribed portion of tissue The two types are molecular death and death "en masse " Bone may be destroyed by pressure necrosis, most commonly due to aneurysms which erode, for example, the sternum and vertebræ

Caries means the molecular decay or death of a bone, following which it becomes softened, discolored and porous

DISPARALLELITY OF VERTEBRAL BORDERS

The presence of this finding means a mechanical derangement This may be either of slow onset or of rapid onset from an acute severe injury This condition may be primary as in congenital scoliosis, or secondary to disease or derangement

THE "NEGATIVE" NEGATIVES

If the x-ray is negative the lesion is doomed to be neglected or at least to be inadequately treated by both the patient and his doctor Two

negatives do not make one positive diagnosis Normal x-rays do not mean the back is normal A man's x-rays may be absolutely normal still he may have a very painful back Another man's x-rays may show considerable changes but he may have no back complaints at the time The x-ray usually reveals old troubles The symptoms and special tests disclose the present trouble

Just as in a case of sprained ankle "negative" x-rays often are followed by "negative" treatment

A frequent report The x-rays show no fracture or dislocation one can be conservative Those cases always recover slowly and often incompletely

Osteophytes may or may not be significant Nerves can get caught by a spur or can be pressed upon or displaced by them

Roentgen ray Interpretation of Vertebral Lesions — The surgeon should not look at roentgenograms until he has studied the history and carefully examined the patient Baetjer warned against making a diagnosis of a bone lesion because it looked like something one had seen before The surgeon should interpret the films himself before he reads the roentgenologist's report One should not express an opinion on a poor diagnostic film Magnifying and condensing glasses as well as strong focal illumination are helpful in examining films

Gross Roentgen ray Requirements —Perfection of technic is essential antero-posterior, lateral and oblique views of the spine will frequently prevent error Stereoscopic views may be helpful All roentgenograms must be marked "right" and "left" They should have the date and if possible the name of the patient and the physician for whom they were taken A "scout film" is one exposed in order to localize pathological change Stereoscopic films show depth as well as length and breadth They are of especial value in visualizing foreign bodies, and the integrity of the 5th lumbar and 7th cervical vertebrae Stereoroentgenometry is a method of determining the solid dimensions of a radiopaque object Ferguson recommended use of films 21 by 36 inches which are helpful in studying the lumbar pelvic and thigh regions at one time They are especially useful in cases of scoliosis The chief value of fluoroscopy in analyzing back disturbances is found in cases of suspected protruded intervertebral disks and spinal cord tumors

Roentgenograms of the spine are always of great positive and negative value There should be antero posterior and lateral roentgenograms of every patient and in some instances stereoscopic oblique and laminographic films It is important to have good diagnostic films to know what to look for and where to look for it and to be able to determine its significance whether present or absent Significant changes are atrophy hypertrophy destruction proliferation rarefaction and osteitis Important anatomical conditions are separation dislocation and subluxation The special parts of each vertebra to be studied are its edges articular facets the foramina the rib joints, the lumbosacral articulations and the sacroiliac joint at its lower edge and its parallel borders The facets are carefully examined for evidence of fracture dislocation osteitis arthritis fusion and anomalies of tropism

Osteophytes, or spur formations on the vertebral bodies are productive changes resulting from the crystallization of the lines of force. These crusty formations at the vertebral margins are due to an effort on the part of nature to stabilize that portion of the spine so it can withstand more strain.

PRE EMPLOYMENT X-RAY EXAMINATIONS

The employer is interested in a reduction in the incidence of industrial backache and a reduced period of disability. Stewart found by pre-employment roentgenographic examinations of stevedores, that 30 per cent of applicants have been eliminated as unfit for this work, the time lost as a result of backaches has dropped by 82 per cent, and the compensation paid has fallen from about 375 days in the first two years to thirteen days in the last two years.

Stewart reported his study of backache occurring in stevedores who had had pre-employment x-ray examinations revealed that a thin intervertebral disk was the most consistent x-ray finding which subsequently was associated with backache. In cases of spondylolisthesis the incidence of backache increased twofold after heavy work. Spondylolysis and spina bifida were not associated with any increased incidence, while asymmetrical facets were associated with a slight increase.

The Oblique Projection is very helpful in visualizing the zygapophyseal joints. Hubeny described a technic especially adapted to detailed study of the lower thoracic vertebræ, the lumbar spine and the upper sacral segments. It is employed to supplement the usual projections. The integrity of the articular facets, the relation of the transverse processes of the 5th lumbar vertebra to the ilia and the relation of the 5th lumbar vertebra to the sacrum are more definitely outlined. The spinous processes of the 4th and 5th lumbar vertebræ are often visualized with greater clarity. It is surprising to get bone detail and architecture far surpassing that obtained by the usual projections.

The usual lateral projection is unsatisfactory in tracing the articular facets, since the superior facets tend to face inward and backward and the inferior facets forward and outward, it becomes apparent that placing the body at an angle is a necessity.

This examination is especially useful in detecting pathological conditions of the facets and is superior to other methods in detecting fractures of the vertebral bodies, dislocations and spondylolisthesis. Oblique projections may be valuable at any level of the spine but at the moment are used more frequently in visualizing certain parts of the lumbar vertebræ. Oblique views of the lumbosacral area show the vertebral articulations in profile and the sacro-iliac joints without bony overlap. In the lateral projection the zygapophyseal joints (articular facets) are situated in the lateral view at gradually increasing distance anteriorly from the midline as one proceeds caudalward. They are, in addition, connected by bone. If one of the joints is situated posteriorly to the one cephalad, or not connected by bone, it means a pathological situation.

Regional Vertebral Roentgenography.—Regional roentgenography includes special technic and interpretation of diagnostic changes in the cervical, thoracic, lumbar, sacral and coccygeal vertebræ, clavicle, sternum,

scapula and ribs In determining the anatomical relation of various structures to each other, a rigid routine is necessary in order that important diagnostic features may not be overlooked

In examining films of the vertebræ one should study the following components body, pedicle, spinous processes, transverse processes, foramina facets, alignment parallelism of borders and shape, size, density and size of intervertebral disks Frankel s law states that normal vertebræ become larger progressively from the head to the sacrum and variations from this such as a narrow vertebra below a wider one, indicate pathological changes in the narrower one

Platispondilia —Putti used the term 'platispondilia' to describe a broad lumbar vertebra

Lumbosacral Region —Those who interpret roentgenograms of the lumbosacral articulation should familiarize themselves with the width of the normal lumbosacral intervertebral disk and the normal relationship of the articular surfaces Oblique films of the lumbosacral region and lower lumbar vertebræ are especially helpful in visualizing defects and lesions of the pedicles and articular facets

COMMON PITFALLS OF ROENTGEN RAY DIAGNOSIS

Roentgen ray Variables —There are many roentgen-ray variables that may be important in patients with back disturbances The chief ones are postural roentgen-ray distortion improper central ray projection, divergent ray shadows and overlap of tissue shadows, especially in the thoracic region in cases of dorsum rotundum

In roentgenograms taken of the thicker parts of the body, such as the trunk or pelvis, some parts of the body will be several inches from the film

Postural roentgenographic distortion is produced by various positions of the patient on the table and the location of the roentgen apparatus

Examination of a film includes first study of the vertebra and then of soft tissue shadows Much information can be obtained from a careful examination of the soft tissues The examiner must determine whether there is a lesion in a vertebra Wide experience in variations of normal positions and in technical details is necessary for correct interpretation The presence of gas in the bowel superimposed on bone may simulate a destructive lesion The age of the patient is a factor in the normal density of the bone Sutherland called attention to the fact that osteoporosis due to advancing age particularly in the vertebra ribs or pelvic bones with tissues or bowel content superimposed will make it difficult to rule out the osteoclastic form of metastasis to bone or destruction from other malignant lesions One looks for congenital anomalies and for traumatic infectious metabolic circulatory myogenic neurogenic and neoplastic changes The basic consideration in the interpretation of roentgenograms of the back is an accurate knowledge of the anatomy so that the interpreter of the roentgenogram knows what to look for and how to interpret abnormalities Important conditions to be studied in a spinal roentgenogram may be divided into the following classes (1) vertebral diseases (2) spinal injuries (3) bone tumors (4) congenital malformations (5) infectious lesions

CHAPTER 9

LABORATORY DIAGNOSTIC AIDS IN BACK DISORDERS

LABORATORY diagnosis depends on examinations of the following organic materials and structures

1 Blood	red blood cell count white blood cell count differential count chemical bacteriological serological
2 Urine	physical chemical bacteriological
3 Foci of Infection	Teeth Sinuses Throat Genito-urinary tract Gastro-intestinal tract
4 Spinal fluid	physical chemical bacteriological cytological biological
5 Biopsy tissue material	

Spinal Fluid —Examination of the spinal fluid is of great value in the diagnosis of poliomyelitis, meningitis syphilis and any condition which causes a partial or complete block in the spinal canal for example, the protrusion of an intervertebral disk or a tumor of the spinal cord or cauda equina

Biopsy Examination —Biopsy is the examination of living tissue Its chief indications are in suspected cases of tuberculosis and tumors It answers the question whether or not a lesion is tuberculous and shows whether a tumor is benign or malignant The diagnostic animals are the rabbit, guinea-pig, and monkey

The Diagnosis of Destructive Spine Lesions by Needle Biopsy —Needle biopsy in spine lesions have been described by Robertson and Valls It can be used with a fair degree of accuracy and a high degree of safety in lesions of the spinous processes laminæ vertebral bodies, intervertebral disks or surrounding soft tissues

Biopsy of Regional Lymph Nodes —Ottolenghi found that biopsy examination of regional lymph nodes is of value in diagnosing tuberculosis

Clinical Significance of Blood Serum Phosphatase.—High concentrations of phosphatase are found in ossifying cartilage. In osteitis deformans, hyperparathyroidism, and rickets the phosphatase levels may be from ten to twenty times above the normal values. In osteitis deformans the calcium and phosphorus values are normal, while in hyperparathyroidism the calcium is elevated and the phosphorus is low; in rickets both calcium and phosphorus are low.

The level of the serum phosphatase gives the most reliable single index for evaluating early and doubtful cases of rickets. In primary or metastatic osseous cancer the values are usually increased from two to five times the normal. Hodges states that values over 10 units per 100 cc. of serum are diagnostic for prostatic carcinoma with metastases.

CHAPTER 10

THE DIAGNOSIS OF BACK DISTURBANCES

BACKACHE may present a complex diagnostic problem, because a number of affections may exhibit similar signs and symptoms. One must consider not only the bones, joints, intervertebral disks, ligaments, muscles, nerves and blood vessels of the back, but also the pelvic and abdominal viscera. The diagnosis of back disturbances is based on

1. An accurate, complete chronological history
2. A complete physical examination made in proper sequence
3. Adequate roentgen-ray investigation
4. Appropriate special tests

The diagnosis may be suggestive, presumptive or conclusive. It should include clinical, etiological, anatomical and pathological factors.

A correct diagnosis must be made as quickly as possible. The guides to physical diagnosis are chiefly muscle spasm, special tests of the back, pelvis and legs, the reflexes and roentgenograms. The physician must bear in mind that a patient with a backache must be examined from head to foot.

In giving the history, many patients forget minor and sometimes major injuries. They unwittingly mislead the doctor in regard to the degree of pain and the duration of their trouble. Information should be obtained concerning the patient's condition before the alleged trauma occurred. The normal back is resistant, but the predisposed back is susceptible to various lesions. A person with intermittent attacks of backache accompanied by pain along the course of the lumbosacral plexus, pain which is aggravated by coughing, sneezing and abdominal or neck straining, is a suspect "disk case." The diagnosis may be a disk lesion or a tumor of either the spinal cord or the cauda equina. One must rule out imbalance of the feet, legs and pelvis.

Specific localized tender areas, demonstrated by palpation, are of great diagnostic value. All possible foci of infection should be searched for. Pelvic and rectal examinations of the female yield information regarding tumors, position of the uterus, pelvic inflammation, prolapsus uteri, cystocele, rectocele, hemorrhoids, fissure, fistula, carcinoma and coccygodynia. Rectal examination in the male reveals the presence or absence of an enlarged prostate, prostatitis, seminal vesiculitis, hemorrhoids, fissure, fistula, carcinoma and coccygodynia.

The examining physician should not hesitate to obtain an expert neurological opinion. The roentgenogram should be used as an aid and not a substitute for other diagnostic measures.

Laboratory tests include the tuberculin, Wassermann, and Kahn reactions, examinations of the blood, spinal fluid, urine and feces. If there is a sinus, a bacteriological examination of the discharge should be made. In certain cases the lesion should be aspirated or explored and the removed fluid and tissue examined cytologically, bacteriologically and pathologically.

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Spinal puncture, manometric studies and intrathecal air or pantopaque injections are reserved for special conditions. The outstanding indications for a pantopaque spinogram is to confirm the diagnosis of a suspected tumor of the spinal cord or protrusion of an intervertebral disk and to localize the lesion if present.

The Diagnosis of Back Disorders Reduced to a Mathematical Formula

Information on Backache

History

1. If these questions are asked properly,
2. If they are understood by the patient,
3. If he answers truthfully,
4. If the examiner knows how to interpret the answers, he should have 50 per cent of the correct diagnosis in 100 per cent of cases and 100 per cent of the diagnosis in 50 per cent of the cases.

Physical Examination.—If the physical examination including a minimal neurological examination is made in proper sequence and the examiner knows how to interpret responses and reactions to special tests, he should have 90 per cent of the correct diagnosis in 100 per cent of cases and 100 per cent of the diagnoses in 90 per cent of the cases.

Roentgen Rays.—If in addition to the history and physical examination, adequate roentgen ray study and interpretation are available, the examiner should have 95 per cent of the diagnosis in 100 per cent of cases and 100 per cent of the diagnoses in 95 per cent of cases.

Special Procedures.—If in addition to the above, the examiner has the benefit of such procedures as installation of contrast media in the spinal canal, special laboratory studies and the therapeutic test of treatment, he should have 99 per cent of the diagnosis in 100 per cent of cases and 100 per cent of the diagnoses in 99 per cent of cases.

History

Do you have backache?
How long have you had backache?
Is this your first attack?
Did it come on suddenly? Gradually?

Localization

Where is your backache? High? Low? Middle? Exactly in midline?
Do you have pains in your legs?

Description of Pain

Is your pain constant? Intermittent?
Is your backache made worse by coughing? Sneezing? Straining at stool?
Are your legs weak?
Do you have any numbness in your legs?
Does your backache waken you out of a sound sleep?
If it does, will moving about relieve you?
Is your pain relieved by rest?
Is it made worse by rest?
Is it relieved by a tight pelvic support?
Is your back tender to pressure? to jars? to twists?
Is your back stiff and painful upon resuming activity after resting?
Do you prefer a rigid or soft mattress?
Is your trouble improving?
Is it getting worse?
What treatment have you had?
What were the results?

CAUSES

Was it caused by injury?
Was it caused by injury during employment? During Military Service?
How many injuries have you had?
Did you ever hurt your back diving?
Were you "athletic" in school?
Have you had any major operations?

SYMPTOMS AND SIGNS

How are your teeth? Throat? Sinuses? Feet?
Are you constipated? What do you do about it?
Have you any urinary trouble?
Do you have control of your bladder?
Do you have control of your rectum?
Do you have any trouble with your pelvic organs? Your prostate?
Do you have hemorrhoids?
Have you any muscle wasting? Legs?
Have you any loss of sensation? Legs?
Can you raise your legs straight up while lying on your back?
Does backache run in your family?
Do you have a sway back?
Are your legs equal in length?
Are your knee jerks present?
Have you had any x rays of your back? When? Recently?
What were you told the x rays revealed?

The examining physician should ask himself several questions, among which are Is the evidence obtained from the history and the physical examination as well as from the roentgen-rays and other laboratory studies, compatible with a certain condition even though not entirely conclusive? Is the roentgen evidence *confirmatory* or *conformatory*?

In the routine "back case" the most important question is "Are we dealing with a space occupying lesion of the spinal canal?"

If we are confronted by a space occupying lesion we are challenged to determine are we dealing with

A disk lesion?
A tumor of nerve tissue? or
A tumor of vertebral parts?

An absolute *differential diagnosis* may be difficult or impossible

• The disk syndrome has at times become a diagnostic football Mixter and Barr called attention to the presence of ruptured disks in many cases of severe back and sciatic pain, with but meager neurological findings •

The cooperation of neurosurgeons and orthopedic surgeons has added a new chapter in the etiological diagnosis of sciatic pain The present concept of this syndrome was established through the evolution and utilization of the knowledge accumulated by many neurologists neurosurgeons and orthopedic surgeons

The symptoms and physical signs might be out of all proportion to the x-rays The examiner should ask himself the question Do the x-rays *confirm or conform* to my suspicion?

The second question is "What does the patient have *besides* what I see in the x-rays?"

Clinical examination alone will usually establish the existence of a disk protrusion and localize its site O Connell believes that the involved nerve

is stretched over a mass of displaced disk tissue and the severity of symptoms is related to the degree of tension within and upon the nerve The clinical diagnosis and the localization of disk lesion are becoming increasingly accurate Cooperation of the roentgenologist neurologist and orthopedic surgeon is essential in determining the exact situation of many back lesions

The most important point in the diagnosis is

"Is there a disk protrusion?" The next question is "If there is one where is it?"

Evidence may be Suspicious presumptive probable positive It may be *conformitory* or *confirmatory*

DIFFERENTIAL DIAGNOSIS OF BACK DISTURBANCES

An accurate differential diagnosis is imperative in order to institute appropriate treatment at the earliest moment To make a differential diagnosis, the physician must know the cardinal symptoms and signs of all back lesions deformities and diseases He must know especially the characteristic physical and roentgen manifestations of every disorder that might affect the back Unlike causes may produce like symptoms, physical manifestations pathological changes and possibly roentgen appearances

The most important conditions to be differentiated, are injuries, tuberculosis arthritis, disk lesions internal derangements, neoplasms neurological lesions osteomyelitis syphilis synovitis scoliosis osteochondritis, apophysitis, poliomyelitis aneurysm rickets and circulatory lesions

Determination of the exact location of the lesion during its early stages demands the greatest skill and painstaking study If the trouble is in the back, it must be localized either in the bones or the soft tissues If in the bones or in the joints the specific regions must be determined

Lesions producing pain in the lumbar lumbosacral and sacro-iliac regions and symptomatic sciatica require keen diagnostic differentiation In no class of disorders presented to the orthopedic or industrial surgeon are the problems of diagnosis and treatment more important than in low-back conditions One of the most difficult points to determine is whether the lesion involves a sacro-iliac or the lumbosacral joint because these articulations are so closely associated anatomically and physiologically that any severe injury or infection may involve one or more of the three joints, rendering the exact location of the lesion difficult and at times, especially during the early stages, impossible No single sign or test is infallible One should emphasize the importance of consistent localized points of pain and tenderness Too much reliance should not be placed on normal roentgenograms, especially during the early stage

Differential diagnosis between severe arthritis malignant tumors and tuberculous spondylitis may be difficult In tuberculosis the intervertebral disks are usually involved while in carcinoma they may remain intact for a long period

To differentiate spinal tumor from tuberculosis of the spine by roentgen examination is not easy Certain valuable points however are available

A vertebral body destroyed by malignant disease is prone to collapse uniformly, producing an "accordion effect." A triangular compression of a vertical body is more common in tuberculosis. This variation in the type of collapse accounts for the fact that a gibbus is usually less marked in a neoplastic lesion than in a tuberculous one. *A firm tumor may destroy a* vertebral body and at the same time prevent any appreciable collapse. A characteristic of tuberculosis is destruction of the anterior portions of adjoining vertebral bodies, an uncommon finding with spinal tumor. Tuberculosis rarely affects the neural arch or its appendages. These parts are frequently sites of neoplastic growths. Tuberculosis shows little tendency toward regeneration of bone, a striking feature with some tumors.

Thirty years ago the differential diagnosis of back disorders revolved around the question "Tuberculosis against the field"; nowadays it is "A disk against the field."

The Differential Diagnosis of the Cause of Backache Includes

1. Mechanical: Bones, ligaments, facets, foramina
2. Traumatic
3. Arthritic
4. Infectious
5. Disk lesions
6. Neurological lesions: central, peripheral, sympathetic
7. Tumors of spinal cord and components
8. Neoplasms: primary, metastatic
9. Dural and epidural lesions
10. Fractures and dislocations

Arthritis.—Arthritis may be recognized from the history, physical findings and the roentgen examination. The disease causes pain, rigidity and sensitiveness to movement. There is no spinal deformity until the condition is advanced, when the deformity is a generally rounded, posterior curve or a flat back. Roentgenograms in lateral projection may show thinning of the cartilage and some narrowing of the vertebral bodies anteriorly, with "lipping" of bone at the articular surface and bridges of bone. *Anteroposterior* views reveal lipping with occasional bridges across the cartilages. Referred pain is due to irritation of the spinal nerves.

Tuberculous spondylitis causes rigidity from involuntary muscular spasm and bone destruction. A kyphos may be due to congenital abnormalities of the neural arch, spondylolisthesis, inflammatory lesions other than tuberculosis, neoplasm or aneurysm. Syphilis of the spine is described in another chapter. I have seen several examples of aneurysm of the aorta eroding vertebræ. Aneurysm of the abdominal aorta may rupture into the sheath of the psoas muscle and produce an abdominal tumor which on palpation may suggest a psoas abscess. A lateral x-ray of the spine may show the characteristic erosion of the vertebral bodies. If aneurysm is suspected, a long fine needle may be inserted into the pulsating mass and some of the

material aspirated If it is an aneurysm blood will be recovered There is practically no danger in this procedure

In tuberculosis of the thoracic spine in a young child, Sayre's test, which is said to be pathognomonic, may be made as follows with the child lying face down across the examiner's knees, a grunting respiration is heard during the period when the knees are brought together after being spread apart

Fractures or dislocations of the spine are diagnosed from the history, examination and roentgenograms A compression fracture always has a history of injury even though the trauma may be slight It usually causes a small kyphos and localized rigidity Roentgenograms reveal the crushed vertebral body "Kummell's disease" or post-traumatic spondylitis is an unrecognized compression fracture of the spine

Aggravation of a Pre existing Condition —It is necessary to recognize cases of pre existing disease in which pain is produced by a slight injury The patient has had the condition for a long time slight injury accentuates the pain and temporarily causes an increase of symptoms One must differentiate between lesions caused by actual injury and pre-existing conditions which are aggravated by a slight injury

Scoliosis —In this deformity the spine is often flexible and, as a rule not tender Pelvic imbalance from various causes may be present There may be a history of poliomyelitis or empyema or the defect may be congenital Roentgenograms reveal the curvature but, as a rule no sign of a bone lesion

Impinging Spinous Processes Producing Bursa or Hygroma —Diagnosis of this lesion is made from an examination of lateral stereoscopic films made while the patient's spine is flexed and when it is extended

Typhoid Spine —This disease may attack the spine during convalescence It produces a periarticular inflammation accompanied by spasm pain in the back and sensitiveness but usually no kyphos

Pyogenic osteomyelitis of the spine is indicated by a history of a preceding infection the acute febrile state and the early destruction of the intervertebral disk Acute osteomyelitis of the spine is uncommon compared with tuberculosis Lesions of the spine which also must be borne in mind are those due to syphilis, or osteomalacia Syphilis may be ruled out by serological tests or by response to specific therapy

Involvement of the Nervous System —The neurological examination may be more important than the roentgenological One gross distinction lies between low-back pain with or without neurological signs and symptoms The subjective "earmarks" of a neurological factor are (1) pain which is worse during recumbency (2) pain which is worse at night (3) relief from pain during sitting, (4) exaggeration of local and radiating pain upon sneezing coughing and straining (5) paresthesias (numbness tingling and formication) One must consider tumors of nerve tissue and vertebral parts and lesions of the intervertebral disks Objectively one may find any or all of the following (1) reflex changes (*a*) increased or decreased patellar and ankle jerks depending upon whether peripheral or central fibers are encroached upon (*b*) abnormal reflexes (the Babinski reflex is found only if the upper motor nerve tract is involved) (2) sensory changes

to touch, pain, temperature and proprioception), (3) motor changes (flaccidity, weakness, atrophy and fibrillation)

Diagnosis of an intraspinal lesion producing low-back pain is based on three factors (1) a history of intermittent pain in the back, with sharp paroxysms in the distribution of the sciatic nerves, associated with numbness or weakness of the affected leg and persisting in spite of conservative treatment, (2) definite abnormalities revealed by careful neurological examination, (3) roentgenographic evidence of encroachment on the contents of the spinal canal following the subarachnoid injection of a contrast medium

Many descriptions of symptoms, signs and physical findings that were formerly offered as evidence of sacro-iliac or lumbosacral disorders fit the syndrome of protruded intervertebral disks Some of our "cut and dried" diagnoses of the past were actually disk syndromes

Neoplasms —Benign osteomas, cartilaginous intervertebral disk protrusions, giant cell tumors, and several other tumors occur in the vertebræ Osteomas may be multiple The history shows that the tumor has been present for a long time and that its growth is slow There is often no pain unless the osteoma interferes with other structures The roentgenograms show that the structure of the tumor resembles that of normal bone Hemangioma of the vertebræ is discussed in another chapter or subsequently Malignant new growths are frequently seen in the spine They cause persistent pain that is not relieved by recumbency Rigidity from involuntary muscle spasm is present Deformity does not occur until there has been considerable destruction of bone In cases of carcinoma there is usually a history of a primary focus in a breast, prostate, thyroid, kidney, adrenal gland or gastro-intestinal tract The roentgenograms will show absorption of the bone calcium and obliteration of the detail structure of the bone suggesting that it is being gradually dissolved As a rule there is no evidence of new bone formation

Sarcoma usually produces a large swelling which develops rapidly In some cases the bone is eroded, but the erosion is not confined to the vertebral body, as is commonly the case in tuberculosis The osteoplastic type of sarcoma shows an increase in the density of the involved bones

Hodgkin's disease of the spine produces symptoms similar to those of tuberculosis or arthritis The lesion is a lymphogranuloma and the symptoms are pain, tenderness, limitation of motion and roentgen-ray findings which may be indistinguishable from those of arthritis

Paget's disease of the spine has an insidious onset After a considerable time a rounded posterior spinal curvature develops There is often local aching in contrast to the distant pain of tuberculosis The diagnosis is made on the basis of roentgenograms which disclose the typical bone changes of this disease in characteristic locations elsewhere in the body *i e*, irregular hypertrophy and rarefaction with linear striations The skull changes are typical It may be impossible to differentiate Paget's disease of the vertebræ from hemangioma

Nutritional and Metabolic Disorders —Rickets occurs during dentition It should be differentiated from tuberculosis, which is rare before the age of two years In rickets one finds a long, round curve, in tuberculosis there

is usually a short angular deformity In rickets, the vertebræ are not well demonstrated on the films because of their low calcium content Usually in the active or first stage of the disease, the bodies are not definitely distorted, but their margins appear "frayed " During the second stage, coarse longitudinal striations are observed with increasing density There is no collapse of the bodies or tendency to fusion The secondary deformities are due to pressure incident to the weight-bearing function of the spine In rickets the deformity is easily corrected because bony destruction and muscle spasm are not present

Rickets is rarely painful Other evidences of rickets include the "rachitic rosary " square head, irregular and broad epiphyses " potbelly " Harrison s groove knock knees, bow-legs, coxa vara and altered calcium and phosphorus levels in the blood Roentgenograms of the tibia show thickening of the cortex on the concave side

Osteomalacia —In the osteomalacias especially the hunger type, which was frequently observed in Germany shortly after World War I there is a deformity of the vertebral bodies manifesting itself in a biconcave impressional defect This is the result of pressure from swollen intervertebral disks on the weakened bodies

Other conditions to be differentiated include protruded intervertebral disks lumbago neuritis Scheuermann s vertebral epiphysitis Calvé s epiphysitis spinal cord tumors myelitis hemorrhage into the spinal cord or canal back strain back sprain and sciatica

Pernicious anemia may cause symptoms referred to the back which can be differentiated with the aid of the history and physical and blood examinations Female pelvic lesions, abdominal and genito-urinary conditions and disturbances of the hip knee and foot will not be discussed here A large number of backaches in women are due to fatigue of the back muscles and according to Sturmdorf, a protective tilting of the lumbosacral articulation In gynecopathic conditions vaginal examination should eliminate the presence of retroversion, prolapse and pelvic inflammatory disease In a review of 3600 case histories backache of urological origin was found in 31 per cent, 620 in female and 507 in male patients Folsom called attention to a reflex from the female urethra that gives the identical backache in women that one gets from the prostate or the posterior urethra in men

Traumatic neurosis is a diagnosis easily made but hard to prove The reader is referred to Chapter 41 for the basic principles underlying traumatic neurosis because the back is a favorite point of concentration Malingering may be suspected from the general behavior of the patient In obtaining the history of a suspected malingerer it is wise to approach the matter from various angles One cannot convince a third person that a man is a malingerer unless that person himself believes it By the relocation test one finds that previously marked areas cannot be relocated with reasonable accuracy Usually the gait and the attitudes on rising and sitting are normal One should watch the patient undress, especially when he removes his shoes and hose Involuntary muscle spasm is not seen in malingerers Actual traumatic areas can usually be localized rather sharply by the patient Non traumatic areas are usually diffuse, with widely

spaced normal areas. Exaggeration, which means magnification of a real condition, always creates a difficult situation. Railway spine, or Erickson's spine, follows injury received on a common carrier, as for example a railway train. It has been facetiously stated that the best treatment is a "greenback poultice."

Hysteria reveals a disproportion between the subjective symptoms and the clinical observations. Other stigmas of neurosis are usually observed. There is more pain but less rigidity, except voluntary muscle spasm. Pressure over the transverse process is not as painful as over the spinous process. This is not true in tuberculosis. Normal roentgenograms assist in making a diagnosis. Camptocormia, or listing of the body to the side, often due to a neurosis, was common during the first World War.

CHAPTER II

PROGNOSIS IN BACK DISORDERS

There is no group of cases in which the problem of diagnosis and treatment may be more difficult and the results less predictable than in back affections. Back injuries may be more serious than similar ones in other portions of the skeleton. The important unknown quantity is the pre-existing condition of the spine. Many injured backs were abnormal before the trauma in question occurred.

The prognosis depends on the etiological factors, the pathological changes, involvement of the spinal cord and nerve roots, the duration of the condition, the resistance of the patient, the persistence of treatment and the question of compensation or the military classification. Prognosis varies in cases of deformity, diseases, and disabilities, and whether the etiological factors are congenital, infectious, traumatic, paralytic, neurological, metabolic, circulatory or neoplastic.

The outlook for recovery varies widely in civil, military and industrial cases. The important factors are: (1) who is responsible, (2) the mental attitude of the patient toward the trouble, (3) the elapsed time before treatment is started, (4) the choice of treatment and the persistence of the doctor and patient.

Because the back is a very complex structure, one should be guarded in his predictions. Unless the disorder is malignant, the outlook in most cases is good so far as relief from pain is concerned.

Back injuries may be accompanied or followed by a train of nervous symptoms which are out of all proportion to the severity of the injury. These nervous symptoms may be genuine so far as the patient is concerned. However, they increase the difficulty of obtaining a good result. In medico-legal and military cases they render the situation more complicated because while the physician may feel sure of the truth of the patient's statements, there may be little evidence to confirm them roentgenographically.

In such neurological conditions as anterior poliomyelitis, spinal cord involvement in fractures of the spine and peripheral nerve injuries, the reaction of degeneration is an important prognostic test. In neoplastic conditions the prognosis depends upon the character of the tumor and the time element, *i. e.*, the interval between recognition and treatment. For example, in many diseases early treatment is uniformly successful and late treatment often unsatisfactory. Delayed lumbosacral trouble may follow fusion of the 12th thoracic and 1st lumbar vertebræ, especially if the operation performed to correct the residual effects of an injury is unduly delayed. In traumatic cases the prognosis depends upon the severity of the injury, the degree of shock, the amount of hemorrhage and the presence or absence of infection. In paralytic conditions, it depends upon the severity of the paralysis and the treatment. One should

sound a warning in regard to the enthusiasm of the person employing the various agents used for symptomatic relief The patient is interested in permanent relief He wants authoritative assurance against recurrence of his trouble

If a mechanical backache is allowed to persist it may develop into a serious problem especially if it is complicated by a psychosomatic factor

When I was a junior medical student a neurologist said to me "If you tell a person there is nothing wrong with him (or her), then both you and he are defeated You must tell the patient (1) there is something wrong (and there usually is) (2) that you know what it is, (3) that you know what to do for it, and (4) that you can do it or you know someone who can

The prognosis for industrial and military disorders is often strikingly modified by psychological considerations Kasanin stated that "35 per cent of female patients who consult the psychiatrist complain of backache which is on an organic basis "

By far the most troublesome back cases and the hardest to appraise satisfactorily, according to Love, are those in which there is litigation pending This group demands the utmost consideration, not alone because of the difficulties involved but also because of the great tendency for people to sue one another, and particularly to sue corporations, in an attempt to obtain compensation for their misfortunes, regardless of whether or not the suit is justified Careful attention should be paid to the taking of the history in these cases, dates of alleged injuries should be recorded The question of compensation and insurance problems should be noted, if it is possible to get the information Physicians who have observed many industrial, automobile, or railroad accident cases know how difficult it is to obtain an excellent result in such cases Likewise, if a patient is carrying disability insurance that will pay him more than his declining income, it is easy to see that it might be difficult to cure him by any type of therapy Insurance companies realize this and the larger companies are very careful about writing policies which would entitle the insured to collect as much as, or more than his income in case of disability

Smith found conservative methods satisfactory in about 90 per cent of patients treated by the orthopedist for low-back pain The results of spine fusion have been excellent or good in more than 80 per cent of the cases This proportion can be increased by greater care in excluding arthritis and other conditions not amenable to surgery and by better operative technic

It is always risky to perform fusion of the spine of any person who has litigation or compensation pending Most orthopedic surgeons who have fused lumbosacral joints to cure backache, have encountered difficulties when the cases are reviewed by compensation boards and insurance companies Some insurance companies categorically refuse permission to perform a spine-fusion operation on any patient over whom they have jurisdiction Before a spinal fusion is advised one should exhaust conservative treatment

The question is asked very often "Do industrial workers return to hard work after bone graft operations?" The answer is "Yes, many do" It depends on the worker, the surgeon, the diagnosis, the excellence of the

surgery and the establishment of confidence in the surgeon. Many compensation "cases" do return to previous occupations.

Every patient should have the benefit of conservative treatment. When a patient does not respond, one must conclude either: That there was more trouble present than was originally diagnosed, or the treatment was either inappropriate or inadequate, or was carried out too late. There will always be some pleasant surprises and sad disappointments.

Neurasthenia or Malingering.—Nervousness or a neurosis seriously complicating recovery often appears in chronic strains of the back. There are according to McBride many sources for such complications: the psychological background, influences of depression, apprehension from litigation procedures, focal infections, general debility, and associated systemic disturbances. A patient so affected must be cared for in a masterful way or he will grow progressively worse. While a satisfactory early legal settlement is often the quickest cure when the psychological element predominates, due caution must be used in eliminating organic causes for the condition.

Persistence of Backache After Operation.—Backache may persist after operation. There may be several explanations for this situation: first, that the diagnosis was incorrect; second, there was incomplete correction of the pathological changes; third, there may be recurrence of trouble due to the superimposition of various factors. There may be other disturbances of an infectious or mechanical nature, *i. e.* pelvic obliquity which was not compensated for. The surgery may not have been technically correct. There may have been poor after care or poor follow-up care by the doctor or the patient.

Symonds is not convinced that a disk operation offers a short cut to recovery in an attack of sciatica due to protruded intervertebral disk or that the prospects of recurrence are any less in cases treated by operation than in medically treated cases. Martin believes that when a protruded disk is removed one has only treated a complication. Some writers believe there are progressive changes in the mechanical set-up of the spine after removal of a protruded intervertebral disk both in cases where a spine fusion was not performed and where it was performed.

The Mental Attitude of the Patient with Backache and Sciatica.—It has been pointed out that the success of the "shady sisters of therapeutics" and the popularity of quackery and charlatanism should impress upon physicians the importance of treating the mind and the emotions of the patient as well as his physical troubles.

The orthopedic surgeon must recognize and evaluate the mental attitude of every patient. These attitudes are materially influenced by his economic or social status. A vertebral fracture in the wage earner of the family presents psychological problems differing from those arising from a similar injury in a high school athlete. The attitude of the patient toward his disease is very important. The esthetic aspect renders a girl especially coöperative; it may also give rise to psychological disturbances. The person affected with chronic arthritis, especially of the deforming type, presents psychological difficulties. Female patients with chronic arthritis

of the lower back, or coccygodynia, are prone to develop problems which are included in the group of psychalgias.

It is becoming increasingly important to study the mechanisms motivating the behavior of neurotic persons. These mechanisms often involve, according to Osnato, social, economic, sexual, educational and athletic or play activities. Unless cured, the neurotic child becomes a neurotic adult. The course and picture of a disease may be modified in many ways by the mental pattern of the patient. The physician's effort to understand the illness and to relieve the suffering must be directed to the mind as well as to the body, to the "whole" individual, because the intellectual and emotional problems often need more attention than the physical. One should not tell a neurotic patient with backache there is nothing wrong, but tell him there is a condition present, and there usually is, which can be cured, or at least strikingly improved. Neurotics do not solve their problems by acts, but by suffering. It is important to educate medical students to realize that they are eventually to deal with human beings with much more than a material body. Moersch found that in the complaints of 40 per cent of the average clinical patients, psychiatric factors were involved, and about 80 per cent of psychiatric patients presented associated organic diseases.

According to Jastrow, the two types of psychoneurotics are the hysterical and the neurasthenic, one restless, agitated, explosive, unstable, overemotional, and the other paralyzed by fear, hesitancy, anxiety and distress. The problem is to inculcate in them the peace and calm needed for living an adjusted life. Every large community needs a "misery clinic." For depressed patients life has lost its zest, they live sad, gloomy, introverted lives. The cry of the hour is neurological distress, and the need is an organization of the wisdom of the physician and that of the psychologist to combat it.

The healthy mind helps the body, and the healthy body helps the mind. Every person is an integration of mental and physical factors, the one aspect of the patient is dependent on the other, and each influences the other profoundly. The effective prescription contains therapeutic elements acting as a specific for the mental as well as for the physical distress.

Home Treatment consists of local applications, massage, heat treatment inductotherm, visits by physical therapists protection against injury and the use of supports

Related treatment includes defocalization of (1) teeth (2) throat, (3) gastro-intestinal tract (4) genito-urinary tract, (5) prostate in men and (6) pelvic organs in women Hemorrhoids should be given appropriate attention The metabolic aspects of the problem include the treatment of arthritis and obesity For persons with low backache who are obese or moderately overweight it is advisable to prescribe a reducing diet The treatment of constipation assumes much importance in some cases

1 Hypodermic of Demerol
2 Ethyl chloride spray
3 Americaine spray and massage
4 Procaine injection of trigger points
5 Manipulation without anesthesia
6 Adhesive strapping of pelvis
7 Rest in bed
8 Fetal posture, if comfortable
8a Proper mattress
9 Foot board in bed
10 Salicylates by mouth—by rectum
11 Tolserol by vein—Tolseram by mouth
12 Curare
13 Pabalate—Bufferin
14 Empirin with codeine
15 Hypo of morphine if necessary
16 Procaine intravenously
17 Seconal for sleep
18 Traction intermittent or continuous—pelvis legs head
19 Crutches to go to lavatory or
20 Commode at bedside
21 Plaster of Paris cast
22 Brace during daytime while ambulatory
23 Belt or corset while in bed
24 Corset reinforced
25 Hot tub baths
26 Physical therapy, infra red short wave Massage as tolerated
27 An electric blanket low heat, or a lighted cradle
28 X ray therapy or radium
29 Manipulation under anesthesia
30 Psychotherapy
31 Posture chairs
32 When ready to walk balance pelvis crutches pad in shoe
33 For arthritics and neuritics Comp E Comp F A C T H Butazolidin (B Z D)
34 *Reserve Trump Cards*
- A Immediate anesthesia and examination or very gentle manipulation
- B Diet—optimal for each person
- C *Reduction of weight*—if indicated
- D *Control water retention*
- E *Attention to fat deposits*
- F Hormones

THE CONSERVATIVE TREATMENT OF BACKACHE

A comprehensive outline includes the basic principles, *viz* (1) Make the patient comfortable at all costs, (2) investigate later

The conservative measures of treatment of backache are Mechanical and medicinal

The Mechanical Measures Are as Follows

1 Flexion of torso trial and effect
2 Proper mattress
3 Foot board in bed
4 Strapping of pelvis
5 Belts—reinforced
6 Braces—must be comfortable
7 Traction
8 Crutches

Every Patient Should Have the Benefit of the Following Measures

1 Bed rest on a firm mattress
2 Sedation—narcotics for a very short period only
3 Manipulation
4 Tolserol intravenously
5 Traction
6 Physical therapy
7 Brace
8 Corset

Medicinal treatment includes Salicylates by mouth salicylates per rectum may help in some cases where narcotics fail

Drugs by mouth per rectum hypodermically or intramuscularly

The sedatives include Demerol by mouth 50 mgm q 4 h , by hypo 100 mgm q 4 h , Dilaudid pantopan methodon codeine empirin compound with codeine Dolophine and Levo-Dromeran Beware of opiates

The *analgesics* that are helpful are sodium salicylate per rectum bufferin pabalate pabirin

The *hypnotics* are seconal for sleep dormison chloral hydrate phenobarbital

Injections include procaine locally or intravenously

HOSPITAL CARE AND TREATMENT OF BACK DISORDERS

After injuries rest is advisable "Early to bed " If you wish "Early to rise "

Recumbent Treatment—When rest in bed is prescribed for a person with backache it is usually advisable to confine him to the hospital so that additional measures can be carried out as they become necessary and a thorough study of the patient can be made. A rigid or semirigid mattress should be used.

Posture in bed—Fetal posture in a Gatch Bed
Posture in chair—Back support
Posture at stool—A stool for the feet
Foot board to push against

One has two choices: viz. fetal posture but with a foot board, or straight recumbency with a foot board.

Strapping and Traction—A wide pelvic adhesive plaster strapping is applied. Traction on the pelvis is carried out by means of a pelvic belt to which weights are attached by ropes. For an average adult, 20 pounds on each side usually suffices.

Office treatment or ambulatory treatment includes:

1. Ethyl chloride spray
2. Americaine ointment
3. Manipulation
4. Physical therapy
5. Strapping with adhesive
6. Balancing pelvis
7. Cushion pads in shoes
8. Crutches
9. Brace
10. Belt
11. Physical therapy again
12. Prescriptions for medicine: Demerol, seconal, tolserol, butazolidin, hormones

Home care includes:

Rigid mattress
Heat
Comfortable posture
Salicylates per rectum
Protection against draughts and injuries
Support day and night
Demerol
Seconal

WALKING AIDS

Walking aids include: Canes, crutches and walkers. One pair of crutches is worth a hundred canes. All regular crutches should have axillary pads and rubber tips. Other style crutches include the folding adjustable cane type and the Canadian type. Every cane must have a heavy rubber tip.

Attention to foot disorders may be required. It is imperative that the pelvis be balanced in cases of inequality of leg length or pelvic obliquity from other causes.

Immediate anesthesia and examination and gentle manipulation are required in some cases

The diet should be optimal for each person, reduction of weight, if indicated, control water retention, attention to fat deposits

NOTE Don t let anyone tell you that tolserol given by mouth is "just as good as tolserol given intravenously It is not

Some experts are 'playing it down ' Others are "playing it up " It is like a special instrument in an orchestra Any symphony conductor will tell you he doesn't call on the oboe player or the french horn in every selection

General Advice in Prophylaxis—Frequent change of activity may prevent trouble The continuous use of any group of muscles predisposes to strain

No amateur should (1) Shovel snow, (2) rake leaves, (3) work in a garden, or (4) work on a farm for more than 30 minutes at one time

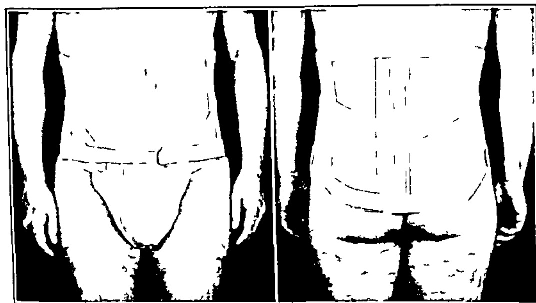


FIG 57 —Support for lower back and abdomen (Courtesy of Dr G E Bennett and Mr H O Kendall) NOTE —Insert 4 V shaped sections of heavy elastic webbing over each groin and over each costal margin

SUPPORTS AND PROTECTION FOR THE BACK

The use of belts or braces is helpful in the treatment of low back pain due to disorders of the lower thoracic and lumbar portions of the spinal column They support the strained or sprained muscles and splint nearby joints and thereby delay the fatigue that precedes pain and spasm of these muscles The purposes are support and protection The prerequisites are comfort and mechanical efficiency

Plastic appliances made of acrylic material are light, cool conforming inconspicuous and sanitary The restraining qualities are rigid

There will come a time when many people will provide themselves with belts and corsets just as they own umbrellas even though it is not raining

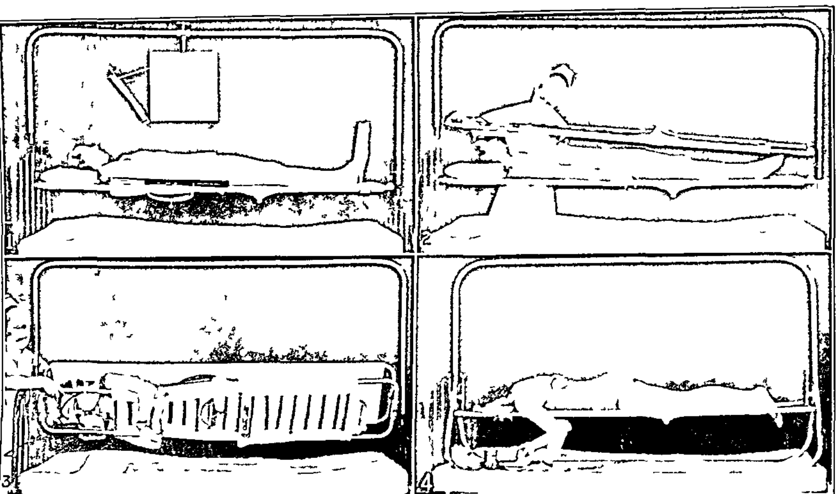


Fig 38 —Four stages in turning a patient by means of the Stryker apparatus Note Feet should be supported in neutral position constantly (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

An efficient corset fits the back in both the sitting and standing positions It must provide an abdominal lift

Polo Belt —Most men and women past forty years of age would be better off if they wore a polo belt while they engaged in any strenuous activity

Most men and women would be better off if they wore a polo belt while playing golf I ask the corsetierre to insert heavy elastic webbing at both sides for resilient support

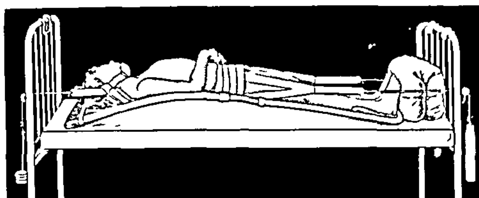


FIG 59 —Head traction and pelvic traction combined with treatment on a curved Bradford frame

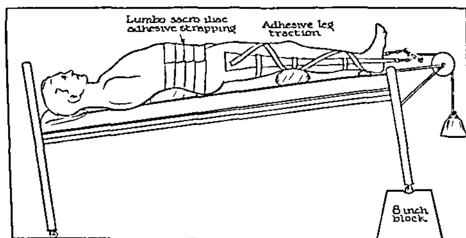


FIG 60 —Leg traction combined with pelvic adhesive strapping

Removable supports are usually not *relievable* Crutches relieve the superincumbent weight of the torso They de accordionize the spinal column by distracting the shoulder girdle from the pelvis

Belts Braces Corsets —Various sacro iliac belts have been designed for sacro-iliac lesions They are also of definite value for some lumbosacral strains For women the corset may be combined with a webbing belt which is to go around the pelvis A sacral pad may be incorporated in the corset

A polo belt serves to support mild lesions in the lumbar area It should have four narrow sections of elastic webbing, two along its upper and two along its lower margins

Depending upon what function a spine brace is expected to perform, the doctor has a variety of designs from which to choose the one best suited to his patient For ordinary support of a weakened back, I prefer the Taylor spine brace (Fig 63) The Kleinberg spine brace is especially useful in cases of poor posture and following poliomyelitis, to prevent permanent lordosis or scoliosis The Bennett-Kendall type of spine brace acts as an abdominal as well as a spinal support I have the sides filled in

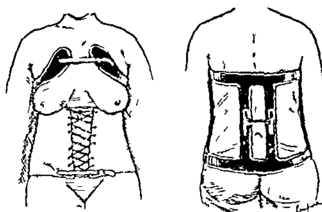


Fig 61 —Cage brace for lumbar conditions (Lewin's Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

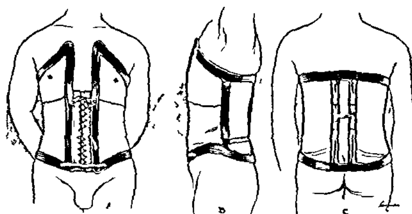


Fig 62 —Cage brace (Lewin's Infantile Paralysis courtesy of W B Saunders Company)

The Hoke corset is made of heavy coutil with double lacing in the back and buckles in front The lacing should be pulled tightly This is best accomplished by partly lacing the back partly buckling the front then completely lacing and buckling

I have found a corset to be of value when support of the lower back is desired It is a non-elastic girdle with a horizontal metal band over the sacro-iliac region and a metal upright along each side of the spine extending to the mid-thoracic region This brace can also be made as a cage brace without the girdle

The Jewett brace is recommended by its designer for the following conditions

Compression fractures of the lower half of the thoracic and entire lumbar spine without complications and for which a hyperextension plaster of paris cast would be routinely employed

Osteoporosis with kyphosis in the aged where hyperextension would prevent further curvature

Adolescent Epiphysitis During the growing period of the spine continued hyperextension will relieve pain improve posture and help prevent deformity

Marie Strumpell's spondylitis (atrophic arthritis of the spine) In the early and not too far advanced cases the maintenance of adequate hyperextension is of great importance in preventing permanent kyphosis

PELVIC STRAPPING

A pelvic strapping—a temporary measure for the relief from pain

It is very gratifying to see a person walk out of your office with a smile and standing upright instead of like a side-wheeler with pain as he walked into your office

A "low back" strapping is a therapeutic myth One must either apply a 'pelvic strapping' or he might as well apply a belladonna plaster or a series of postage stamps or nothing

It is wise to order a brace and corset to be ready for application when the adhesive is removed The brace is used for the daytime the corset for night time

Technic of Application —I make a large 'paint brush of three thin wood applicators secured with a strip of adhesive and wound with a large pledget of cotton I keep compound tincture benzoin in a wide-mouthed short bottle

The plastic material called Sealskin' is excellent I have tried to find non-irritating material that could be sprayed on like Krylon but have not been successful I am trying aeroplast

1 The doctor paints the entire area to be covered, with compound tincture of benzoin or 'Sealskin' or aeroplast

2 A sheet of muslin or stockinette about 10 inches wide and 2 feet long is placed transversely across the lower abdomen and upper pelvis

3 The patient stands with his back toward the doctor who sits on a chair and locks' the patient's legs with his knees

4 A strip of 3 inch adhesive is started in front over the left iliac fossa and is pulled tightly across the back of the pelvis ending in front over the right iliac fossa

5 Strip 2 overlaps the upper half of the first

6 Strips 3 and 4 extend successively toward the thoracic margin, covering the lumbar area

7 The patient then turns facing the doctor

8 Strip 5 begins behind the patient's right iliac crest and passes snugly across the lower abdomen ending behind the left iliac crest

9 Strips 6 and 7 pass successively toward the costal margin covering the entire abdomen

10 The patient turns around again and Strips 8, 9, 10 and 11 are placed over the original Strips 1, 2, 3 and 4

The adhesive strapping should remain in position for a period of four to ten days If sufficient relief is obtained during this period, the subsequent support will depend on the nature of the lesion

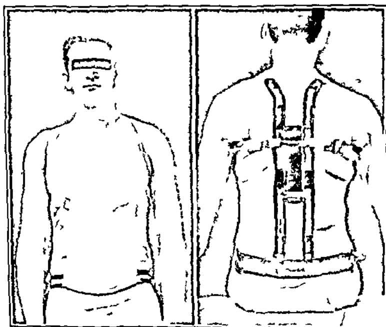


Fig 63 — Taylor spine brace used after an operation for tuberculosis of the 2d lumbar vertebra Technic combined Hibbs Delagenière-Lewin (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

PLASTER CASTS

The purposes of a cast are support protection and immobilization The posture of the patient during application *i e* standing sitting or recumbency depends upon the situation at hand

BODY CAST SYNDROME

In 1920 I applied a body cast to a physician who had arthritis of the spine Within twenty-four hours he had epigastric pain and expectorated blood Removal of the cast was quickly followed by complete relief of all symptoms A spine brace was then ordered I concluded he had gastric hemoptysis on a reflex basis due to irritation of his celiac axis plexus There was a definite emotional overlay Dorph found that excessive vomiting may result from gastric dilation caused by pressure of a body cast

The cast should be removed immediately A Levine tube should be placed in the stomach and appropriate local and general treatment instituted

CHAPTER 13

PHYSICAL THERAPY IN DISORDERS OF THE BACK

THERE is no section of the body where physical therapy results in more remarkable improvement and often cure than the back.

Physical measures are important adjuncts in the care of injuries, deformities, disabilities, and diseases of the back. These remedies are thermal, chemical, mechanical and electrical. The three oldest remedial agents are rest, heat and massage.

The benefits of physical therapy are based on: (1) the effect upon the local and general blood circulation, (2) local absorption of tissue products, (3) relief from pain, (4) relaxation of muscle spasm, (5) relief from adhesions, (6) increase in movements, (7) raising the threshold of the patient's resistance, (8) the psychological effect during the various stages of disease, injury or disability of the back.

Physical therapeutic agents are: rest, heat, massage, manipulation, medical gymnastics, electro-therapy, hydrotherapy, occupational therapy, mechanotherapy, phototherapy, climatotherapy, marinotherapy (thalassotherapy), heliotherapy, colonic therapy, roentgen-ray therapy and radium therapy.

Advice to the Physical Therapy Technician.—Carry out the doctor's orders as a druggist would fill a prescription. Beware of deep massage over hairy areas in case of myositis of the neck, lower back and leg. The physical therapist should encourage the patient to use his muscles and move his joints. A knowledge of anatomy, physiology, biomechanics, kinesiology and circulation is fundamental. Students of medicine should be given practical instruction in the principles of physical therapy.

The back conditions in which physical therapy is beneficial are: sprains and strains, arthritis, neuritis, myositis, fibrositis, fascitis, bursitis, anterior poliomyelitis, rickets, scoliosis, fractures and dislocations.

Back sprains respond to rest, corsets and heat. When walking is permitted, one must prescribe a proper walking shoe with modifications, massage and exercises. In some cases crutches relieve much strain on the back.

HEAT

Heat is one of the most valuable of all physical agents in back disturbances. Dry heat is obtained by means of a hot water bag, electric light, electric pad, bakers, infra red lamp, electric light cabinet, sun, diathermy and inductotherm. Heat may also be produced by ointments, liniments and plasters. Moist heat includes hot applications, steam baths, and mud baths.

HOT PARAFFIN WAX TREATMENT FOR BACK DISTURBANCES

Technic —The patient should be placed on a table, in the prone position with a pillow under his abdomen and his feet projecting floorward over the foot of the table A sheet of impervious material like oilcloth, or oilsilk is placed under him

The back is covered by several thin coats of paraffin which adhere to, and congeal on the skin This is repeated about ten or fifteen times or until there is a heavy coating of paraffin Then the back is covered with a blanket for fifteen minutes The congealed paraffin is then removed and replaced in the bath

The paraffin must be applied quickly and smoothly for the skin should be uniformly covered by each coating The hot paraffin can be painted on the back with a large brush or poured on from a cup or pitcher

The technic most commonly used is to pour the paraffin into a pitcher The operator then starts at the top of the back at the right scapula and in one clean sweep covers the entire right side The same procedure is followed covering the left side This coat adheres to the skin The procedure can be carried out better by a two-person team As one pours the other fills the pitchers

HYPERPYREXIA

Hyperpyrexia fever therapy, pyretotherapy or "friendly fever," means the therapeutic use of increased body temperature Artificial fever can be induced by hot bath, foreign protein, vaccines the inductotherm cabinet or by diathermy The fever can be accurately controlled It permits dosage both in time and degree It is employed chiefly in arthritis, neuritis, myositis and fibrositis It is especially helpful in cases of gonorrheal arthritis where the results are often dramatic

Every candidate for fever therapy should have had a complete physical examination supplemented by routine laboratory studies

MASSAGE

Massage is of value when given by a skilled person under a physician s direction It is most effective when it follows the use of radiant heat, warm compresses or baths It is indicated especially in sprains strains dislocations, fractures stiff joints and after poliomyelitis It aids the restoration of circulation upon which the repair of recent and old injuries depends Massage has three chief indications (1) to improve or maintain adequate circulation and drainage in the neighborhood of the involved joint (2) to improve or correct faulty physiological processes in soft structures and especially the muscles, (3) to compensate for the lack of muscular activity

HYDROTHERAPY

Hydrotherapy is the application of water at various temperatures and pressures and with various constituents as therapeutic agent Its value

lies in the effect upon the circulation of the skin and the tonic action upon the nerves locally and generally

EXERCISES

Medical Gymnastics —Medical gymnastics and exercise include muscle education, re-education and muscle power building Its chief value is found in the treatment of patients with poliomyelitis scoliosis, arthritis postural disturbances and neuromuscular conditions The equipment of the gymnasium consists of stairs parallel bars upright bars wall ladders, stall bars, tables, benches chairs, balance boards wall mirrors, wall exercisers, traveling rings, horses and floor mats

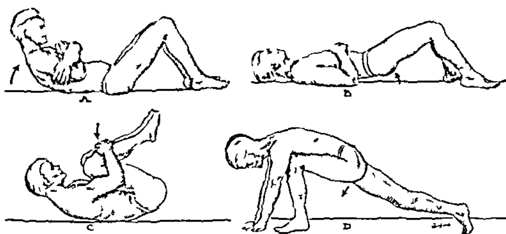


Fig 64 —Exercises recommended by Williams in certain cases of back disorders (Personal communication)

One is continually faced with the problem of rest vs exercise My golden rules are Never exercise irritated tissue, no exercise should be performed that causes discomfort Few persons realize how much exercise they get during their routine daily activities without doing special exercises at specified times

Ballet Dancing —There is no better, more enjoyable or pleasant field of medical exercise for girls than ballet dancing It furnishes an excellent field of neuromuscular education or re-education It is valuable in developing proper posture, grace poise balance, concentration, neuromuscular coordination, physical training and development, mental training and combined physical and mental coordination

Mechanotherapy —There is no doubt that there is value in apparatus but one should not lose sight of the fact that "there is no substitute for human hands and brains"

ELECTROTHERAPY

Electricity is of value because it tones up the system and retards atrophy of muscles Ultra-sonic therapy is being explored

Diathermy.—Diathermy means the use of a high-frequency current to generate heat within a part of the body. The therapeutic effects are limited to the heat produced. Diathermy increases metabolism, eliminates stasis, promotes healing and allays pain. Among the disorders most amenable to diathermy are sprained joints, inflammatory phenomena accompanying fractures, arthritis and inflammation without suppuration in which heat tends to hasten the resolution of the inflammatory products and thus shorten disability.

HELIOTHERAPY

Heliotherapy means treatment by means of the sun's rays. Ultra-violet radiation stabilizes calcium and phosphorus metabolism, converts the sterols and ergosterols of the skin into vitamin D, fixes calcium, phosphorus and iron in the tissues, stimulates the regeneration of bone and skin, increases the percentage of hemoglobin, stabilizes the red and white blood count, increases the flow of blood and lymph, has a sedative action on the central and sympathetic nervous systems, aids in the regeneration of granulation and epithelium and makes the patient feel and look better.

PHOTOTHERAPY

Phototherapy means treatment by various lights. The two main types of lamps are quartz and carbon. Lamps may be air- or water-cooled. The dosage depends on the type of light used, individual characteristics, the distance from the body and the duration of exposure. The application of ultra-violet rays to the back is followed by beneficial local and general reactions.

OCCUPATIONAL THERAPY

Occupational therapy means treatment by means of physical and mental occupation. It is "the science of prescribed work." The following definition of occupational therapy was formulated by the Boston School of Occupational Therapy and quoted by Kidner: "Occupational therapy aims to furnish a scheme of scientifically arranged activities which will give to any set of muscles or related parts of the body in cases of disease or injury just the degree of movement and exercise that may be directed by a competent physician or surgeon. It may be diversional, curative or pre-vocational. Occupational therapy provides a means of conserving and bringing into play whatever remains to the sick and injured of his capacity for healthy functioning." Slagle says "it is directed activity and differs from all other forms of treatment in that it is given in increasing doses as the patient's condition improves." The psychological aspect is important.

Occupational therapy includes any mental or physical activity which is definitely prescribed in some back conditions and guided for the purpose of hastening recovery from disease or injury. Galen in 172 A.D. wrote: "Employment is nature's best physician and is essential to human happiness." The therapist must have a working knowledge of joint and muscle action of the back, *i. e.*, kinesiology.

CORRECTION OF STATIC PHYSICAL DEFECTS

In all back conditions static defects should be corrected especially those of the feet and ankles Inequality of length of legs producing pelvic imbalance should be corrected or compensated for Low backache resulting from foot imbalance can be relieved by the modification of the shoes Many indefinite backaches which fail to clear up under ordinary treatment are relieved by raising the heels of the shoes and by stretching exercise When the heels are raised the body is tipped forward, this relieves the strain on the tense back and hamstring muscles The pelvis must be balanced by building up the shoe of the short side both in and outside, or reducing the height of the heel on the long side

The relation of the foot and ankle to back disorders is one that has been argued pro and con Many people with back disturbances have foot and ankle disturbances Sometimes one antedated the other There is no doubt that a "bad back" does not help good or 'bad feet" Undoubtedly flat feet weak feet, knock-knees and bow-legs may affect the back very materially, especially the lumbosacral joint, the lumbar vertebræ and the sacro-iliac joints The subject has been overemphasized and it is high time that the medical profession became educated to the correct concept of the relation of the foot and ankle to back disorders One may be primary — the other may come later and still not be secondary to the original Correction of the foot and ankle condition is imperative whether or not it bears a causal relationship to the origin of the backache or to its chronicity It is a fact that correction of foot and ankle mechanics and statics rarely cures a definite back condition however it should be done in the interest of the patient's health just as an infected tooth or tonsil should be removed whether either is the cause of arthritis or not

Relation of Shoes to Backache — The effect of various types of heels has been considerably discussed One authority says that patients with backache should wear low heels Another thinks that most women with backache can be relieved of some of their discomfort by changing to higher heels There is no doubt that both groups are correct This matter must be taken care of by the doctor who analyzes each case on its merits, *i e*, on the body build of the person and the mechanical condition present No doubt certain occupations predispose to backache, for example, those in which a person must maintain poor posture during work The influence of bad posture due to occupational strain and stress may be very definite especially upon the articular facets the intervertebral disks, and the lumbosacral and sacro-iliac joints

Mattresses — Every person with backache should be advised concerning the best type of bed and mattress for him A soft mattress may aggravate a backache Most patients sleep more comfortably on a firm bed There are several combinations of springs and mattresses that provide this service Some patients can sleep better on a cushion on the floor than in a bed, chiefly because of the firm foundation

Every person who has backache should try a rigid mattress Continuation of this practice depends upon the patient's response or reaction

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tendons and ligaments. The art of manipulation should be possessed by every surgeon. It is a delicate procedure and the technic must be exact because errors are often disastrous.

Manipulation is no mystery to anyone who understands the pathological changes in these tissues. Manipulative surgery has, to a considerable degree, fallen into the hands of unqualified practitioners because the public assumes that the irregular practitioner has some hidden knowledge, divine gift and peculiar skill. He has an additional unrestricted power to publicize and advertise his successes, but most of his mistakes and failures are concealed by his disillusioned victims or even buried with them. There is no God-given skill conferred on any group of practitioners.

Manipulation of the back requires a fundamental knowledge of the anatomy, physiology and pathological changes of joints and their surrounding tissues. Sir Robert Jones emphasized the fact that there is nothing in the science of manipulation which cannot be safely undertaken by a surgeon who possesses a knowledge of the pathological changes and anatomy of bones and joints, but he must become familiar with methods of manipulation which are safe and thorough.

There are many reports of manipulative dislocations of the cervical vertebrae that resulted in death.

All concepts and writings on low back manipulation must be thoroughly revised in the light of the recent development regarding disk disorders.

I have taught for many years that cervical manipulation was "dynamite." I was referring to the facets, foramina and nerves. One must be especially cautious because of the disks.

Goldthwait warned the profession to beware of hyperextension.

Manipulation of the back, neck and pelvis is analogous to performing the routine examination of these parts more thoroughly than is done for diagnostic purposes. Stiffness of the joints of the back may be due to the presence of adhesions or tightness of the fibrous tissues surrounding them.

Hippocrates employed manipulation. Goldthwait reproduced Hippocrates' illustrations. Hugh Owen Thomas employed manipulation extensively with good results. Sir Robert Jones in England and Goldthwait in America carried on the work. Others in this field were Hilton, Baer, Magnuson, Cox, Cyriax, Elmslie, Bankhart, Bristow, Fisher, Marlin, Jackson, Mennell, Abts, Tyrell, Froedsson, Travell, Pitkin and Pheasant, Jostes, Lewin and Taylor.

Manipulation of the back presupposes (1) thorough physical examination of every patient, (2) adequate diagnostic roentgen films, (3) selection of cases, (4) recognition of contraindications, (5) technic, (6) after-care.

The manipulator must temporarily transpose his brains, eyes and ears to his fingers and hands. Just as force is not needed to make any intricate piece of apparatus work, so when out of order, it can usually be adjusted by gentle manipulation. In difficult cases a series of manipulations is preferable to the use of considerable force during any one session. Tearing of tissues necessarily means more fibrosis, more adhesions, and the back may be *much* more limited in its motion than before.

Manipulation may be accomplished with or without the aid of anesthesia.

Soft Mattress Sequence.—1. At first the *body moulds the mattress* to the *body form*. 2. Then the *mattress moulds the body* to the *mattress form*; or 1, the mattress assumes the shape of the body, then 2, the body assumes the shape of the deformed mattress.

Seating.—Ideal seating design should provide an angle of more than 90 degrees between the seat and the back, preferably 15 to 20 degrees more, so that one may lean against the slope and thus permit the force of gravity to take some of the load off the muscles. Travell prescribes that the ideal chair should provide a stable support for the lower part of the back with maintenance of the normal lumbar curve by a moderate amount of pressure. The insecure swivel back chair will never give such support. The chair should provide support for the upper part of the back at shoulder level. That requires a chair that has a flat-back in its upper portion. The Windsor or barrel-shaped scoop chair is to be avoided. It distorts the upper part of the back by rounding the shoulders forward. To those who sit twisting and turning in chairs that have at least three major faults, Travell recalls an old Greek proverb which reads: The mind can absorb no more than the seat can endure.

Keegan has reported some excellent observations on this subject.

Auto seats, truck seats and farm vehicle seats must be correct or backache will surely follow continued use thereof.

ROENTGEN THERAPY FOR BACK LESIONS

Roentgen therapy has been recommended for vertebral tumors, arthritis, synovitis, bursitis, neuritis, Hodgkin's disease and tuberculosis. The beneficial effect is thought to be due to a change in the local pH from alkaline to acid. In the presence of synovitis and arthritis the disability is lessened; pain, stiffness and other symptoms are reduced.

The application of the roentgen rays may be beneficial to tuberculosis of the vertebrae. Sinuses may close and mineral salts may be re-deposited in decalcified bones. Neuritis may be relieved by roentgen treatment applied to the spinal roots and ganglions or to the affected region itself. It may also help symptomatic sciatic neuritis. In cases of intercostal neuralgia single applications may yield relief.

Radiation Sickness.—These can be minimized by improved roentgen technic, the use of seconal and the ingestion of copious fluids, especially with adequate glucose. Vitamin B_1, Dramamine or Vitamin B_6 are usually very effective.

RADIUM

Radiosensitivity of Vertebral Lesions.—It is evident that radium therapy will accomplish the same results as roentgen therapy, but it takes longer and may affect normal bone adversely.

MANIPULATIVE THERAPY

Manipulative treatment of the back is the art, science and practice of the non-operative restoration of function of the bones, joints, muscles

After-care —The surgeon must be willing to supervise the after-care If possible, physical therapy should be given the same afternoon and night One should avoid narcotics and keep the back in active movement if possible The patient is instructed in simple exercises which should be performed for a few minutes morning and evening "A stretching a day keeps adhesions away" Conwell says "Force the patient but not the joint"

If pain persists for a long period after manipulation, rest is indicated When increased range of movement is maintained after manipulation, further movements may be prescribed But if, in spite of movements, the range is continually diminishing rest is indicated Voluntary movements are most valuable



Fig 65 —The first step in the manipulation which has been found to be most efficient in the reduction of sacro-iliac slips and sacrolumbar subluxations One of the subject's hips has been flexed and the other has been extended The operator is about to rotate the subject's pelvis toward the extended hip and simultaneously to draw the inferior hip backward beyond the center of the table (second step) (Pitkin and Pheasant courtesy of Jour Bone and Joint Surg)

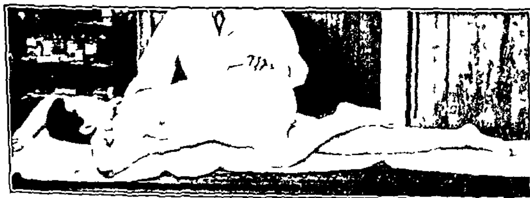


Fig 66 —The third step in the manipulation (The second step has been completed and the pelvis has been *rotated until* the normal limit of spinal rotation has been reached so that the posterior shoulder is beginning to rise from the table The fact that the sacrum is strongly tilted toward the superior hip readily can be deduced from the curve of the linea alba which reflects the left lumbar scoliosis and from the positions of the anterior superior iliac spines in relation to the iliac crests which reflect the left pelvic torsion) The operator presses gently downward and forward upon the superior ilium and upward and backward upon the posterior shoulder thus adding to the rotatory *force* a distracting force that tends to reverse the sacral tilt (Pitkin and Pheasant *courtesy of Jour* Bone and Joint Surg)

Contraindications —Before manipulation is carried out, one must rule out tuberculosis osteomyelitis acute infectious arthritis neoplasms spondylolisthesis prespondylolisthesis protrusion of an intervertebral disk and spinal cord tumor Manipulation should be avoided in cases of elderly and feeble patients

General Precautions on Manipulation of the Back Pelvis and Legs

1 Never manipulate in the presence of tuberculosis osteomyelitis, acute infections, acute arthritis sepsis disk lesions or neoplasm

2 There must be no signs of active infection

3 Never manipulate without a check by recent roentgenograms

4 Never manipulate an arthritic patient without uric acid determination of the blood to rule out a gouty process

5 Complete relaxation usually requires ether anesthesia

6 The fact that the patient is asleep does not give the physician the right to hurt him

7 "Non vi sed arte" Not by force but by skill

8 "You can always go back for more

9 Remember the bones are usually atrophic but the ligaments are not the bone will break or be crushed before the ligaments 'give'

10 Remember that bone and joint changes are always worse than the roentgenograms indicate

11 Breaking an adhesion causes hemorrhage and hemorrhage is the starting point of another adhesion

12 A stretched adhesion causes pain, a torn adhesion does not cause so much pain therefore do not stretch adhesions break them

13 Never manipulate unless you are prepared to supervise the after-care

14 The patient should make active movements at the earliest possible moment following the manipulation

Indications for Manipulation —Manipulation may be employed in certain cases with adhesions, in functional or hysterical cases unreduced dislocations or subluxations and in a miscellaneous group of back lesions It is beneficial in lesions due to adhesions rather than to arthritis

Preparation of Patient —The general preparation of the patient is the same as for an operation Manipulation of the back pelvis and legs may be done under spinal anesthesia

Technic of Manipulation I prefer to manipulate the back pelvis and legs while the patient is on the floor The sense of touch a careful blending of caution and determination in technic are more important than physical strength on the part of the operator The use of extreme force may lead to injury of important structures Goldthwait disapproves of any manipulation that hyperextends the spine

A most important point in manipulation of the back is protection of the patient s head and neck against any sudden twist

Manipulation with Aid of Anesthesia —For the patient whose pain is too severe to allow satisfactory relaxation anesthesia with ether is advised He is placed supine on a mat which has numerous hand-straps on each side As soon as he is completely anesthetized the mat is lifted by 4 or 6 persons and carefully placed on the floor

After-care.—The surgeon must be willing to supervise the after-care. If possible, physical therapy should be given the same afternoon and night. One should avoid narcotics and keep the back in active movement if possible. The patient is instructed in simple exercises which should be performed for a few minutes morning and evening. "A stretching a day keeps adhesions away." Conwell says, "Force the patient but not the joint."

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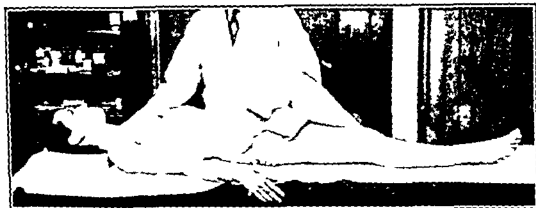


Fig. 65.—The first step in the manipulation which has been found to be most efficient in the reduction of sacro-iliac slips and sacrolumbar subluxations. One of the subject's hips has been flexed and the other has been extended. The operator is about to rotate the subject's pelvis toward the extended hip and simultaneously to draw the inferior hip backward beyond the center of the table (second step). (Pitkin and Pheasant, courtesy of Jour. Bone and Joint Surg.)

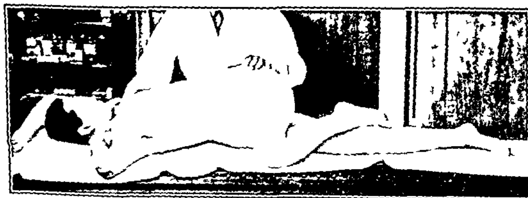


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Accidents very commonly occurring during back manipulation, are (1) dislocation of a hip, (2) paralysis of the external popliteal nerve, (3) avulsion of the achilles tendon from the triceps suræ muscle

Jackson has had one instance of peroneal nerve paralysis following manipulative treatment and has learned of two other instances of its occurrence after treatment given elsewhere He finds that this complication can be prevented by maintaining slight flexion of the leg on the thigh throughout the procedure, by the application of a plaster-of-Paris cast

Lewin's Manipulative Procedure —The following is a comprehensive manipulation which the author recommends for stiffness or tightness of the back and pelvic tissues

1 Flex the thigh on the unaffected side on the abdomen (knee flexed)

2 Flex the thigh on the affected side

3 Flex the thigh on the unaffected side (knee extended), *i e*, perform the Lasegue test

4 Flex the thigh on the affected side till the toes approach the patient s head

5 Perform the fabere-Patrick maneuver on the unaffected side

6 Repeat the maneuver on the affected side

7 Stretch the achilles tendon of the unaffected side (in case of unilateral sciatic pain)

8 Stretch the achilles tendon of the affected side

9 Stand over the patient straddling his body lock both hands under his lumbar spine and hyperextend the lumbar region (caution)

10 Perform the Gaenslen maneuver on the unaffected side, then on the affected joint side

11 Do the Magnuson manipulation on the unaffected side then on the affected side

12 Do the Cox manipulation

13 Then remove the ether mask Elevate the patient to the sitting position Hold his head firmly hyperflex his back until his head can be placed between his knees Bend the back toward the affected side Bend the back away from the affected side

14 Restore the patient to supine position and repeat maneuvers 3 and 4

15 Do straight leg raising on the unaffected side, then on the affected side

16 Forcibly hyperflex both thighs at the same time on the abdomen while both knees are held in extension, *i e* double exaggerated Lasegue or double Kernig test

17 Do the Ober maneuver on both sides

18 If a good sacro-iliac belt is not at hand strap the entire pelvis with adhesive tape

19 If the involvement is unilateral apply leg traction to the affected side and elevate the foot of the bed about 8 inches For sciatic scoliosis one should stretch both sides, the unaffected side first and not so severely as the one affected

The results of manipulative technic suggest that the sacrum is always displaced backward and must be pushed forward Travell described a manipulative technic for the reduction of sacro iliac displacement de-



Fig. 67 — Baer maneuver for sacro-iliac manipulation (Subject is a professional model) (Lewin courtesy of Surg Clin North Amer)

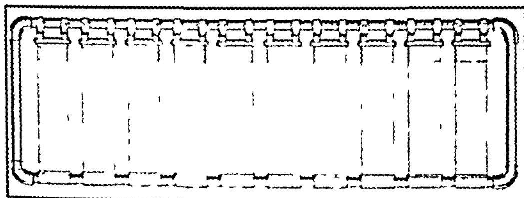


Fig. 68 Bradford frame (Zimmer Co)

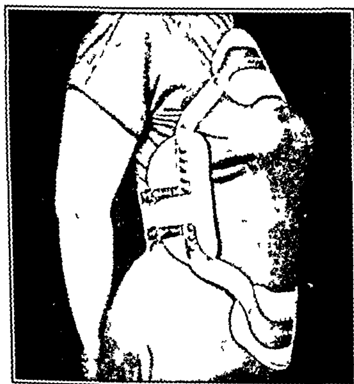


Fig. 69 — Side view of hyperextension brace (Jewett J Int Coll Surg)

veloped by her father more than forty years ago She describes her corkscrew manipulation as follows

The patient lies on his side on a low couch His painful side is upward Muscular relaxation is essential The operator stands in front of the patient One hand slightly overlaps the sacrum and grasps the upper ischial tuberosity, the other hand grasps the front of the upper shoulder Simultaneously the shoulder is pushed backward and the buttock forward and upward, so that the hand on the hip travels in a spiral or corkscrew-like curve This maneuver causes lordosis of the spine The force is applied smoothly and steadily without jerks to effect gradual stretching When maximum rotation of the trunk is obtained, a quick final thrust is made

In some cases the manipulation is accompanied by a clicking sound

Patients ask "Doctor how does it happen that the 'manipulation experts' are doing so well?" The answer is "It is due to inertia of many members of the medical profession, *i e*, disinterest and ignorance"

There is no doubt that some "manipulators" are very skillful but *everyone* gets the same general type of mechanical treatment, which cannot *always* be correct

In direct proportion to the improvement of regular practitioner's service, the "success" of the irregulars will be diluted

SOME GENERAL REMARKS AND PERTINENT QUESTIONS ON TREATMENT

The surgeon should ask himself What to do? What not to do?

When one needs expert help the surgeon should be guided by the following rules

Soothing measures are always preferable to irritating ones

One should never irritate in the presence of an irritative lesion

One should not add *insult* to *injury*

Anything that hurts is wrong

Anything that feels good is likely to be good, unless carried to excess

I have seen much harm caused by vigorous active and passive exercises, performed during an irritative phase

Weight reduction may be important The lumbosacral joint cannot be brought into normal flexion if it must assume the full burden of support of a large abdomen

CHAPTER 14

OPERATIVE TREATMENT OF BACK DISORDERS

OPERATIONS on the back when performed with all the modern safeguards, are attended with but slight risk. With asepsis, antisepsis, strict "no touch" technic supplemented by chemotherapy, the back can be opened with a feeling of security.

There have been significant refinements in technic which permit more rapid operating with less hemorrhage, less shock and greater success.

The Chief Objectives of Surgery on the Back are
To relieve pain To cure disk disorders To correct fractures and dislocations To fuse a section of the back To correct deformity

The chief indications include tuberculosis, scoliosis, tumors and disk lesions.

The patient should understand thoroughly the significance of having part of his back made rigid. This increases the load placed on contiguous non-fused areas.

One should never forget basic principles. No one should do a routine major operative procedure on the back of a man of fifty or over without a previous examination by an expert urologist. It is wise to have the patient know a urologist. If urological symptoms arise after spine surgery, the treatment should be delegated immediately to a urologist.

Every person about to be operated on for a mechanical back condition should be advised that his quadriceps extensors must be kept in good tone during the enforced inactivity.

The first surgical spinal fusion was performed by Hibbs in January, 1911. A few months later Albee announced his method of spinal splinting by means of tibial grafts.

Spine fusion is like pouring molten asphalt on a rough brick road and smoothing it over.

THE QUESTION OF OPERATING ON THE SPINE

The decision to operate on a spine should not be made until the following four points have been determined:

1. Does the person need the operation?
2. Will the proposed operation cure him?

veloped by her father more than forty years ago. She describes her corkscrew manipulation as follows:

The patient lies on his side on a low couch. His painful side is upward. Muscular relaxation is essential. The operator stands in front of the patient. One hand slightly overlaps the sacrum and grasps the upper ischial tuberosity; the other hand grasps the front of the upper shoulder. Simultaneously the shoulder is pushed backward and the buttock forward and upward, so that the hand on the hip travels in a spiral or corkscrew like curve. This maneuver causes lordosis of the spine. The force is applied smoothly and steadily without jerks to effect gradual stretching. When maximum rotation of the trunk is obtained, a quick final thrust is made.

In some cases the manipulation is accompanied by a clicking sound.

Patient asks: 'Doctor, how does it happen that the 'manipulation experts' are doing so well?' The answer is: "It is due to inertia of many members of the medical profession, i.e., disinterest and ignorance."

There is no doubt that some "manipulators" are very skillful but *everyone* gets the same general type of mechanical treatment, which cannot *always* be correct.

In direct proportion to the improvement of regular practitioner's service, the "success" of the irregulars will be diluted.

SOME GENERAL REMARKS AND PERTINENT QUESTIONS ON TREATMENT

The surgeon should ask himself: What to do? What not to do?

When one needs expert help, the surgeon should be guided by the following rules:

Soothing measures are always preferable to irritating ones.

One should never irritate in the presence of an irritative lesion.

One should not add *insult* to *injury*.

Anything that hurts is wrong.

Anything that feels good is likely to be good, unless carried to excess.

I have seen much harm caused by vigorous active and passive exercises, performed during an irritative phase.

Weight reduction may be important. The lumbosacral joint cannot be brought into normal flexion if it must assume the full burden of support of a large abdomen.

Operating Room Equipment

Cotton patties with long silk strings attached
Radiopaque sponges
Retractors
- Hibbs
- Bennett spikes
- Taylor's
- Self retaining
- Watson Sharp
- Lucite retractors (Ghormley) for concentrated light
- Lewin lamina spreader
- Cloward spreader
- Nerve retractors of Love, Key and Cloward

Screws King, Merle D'Aubigné with washer
Metal plates Wilson
Acrylic plates Judet
Roger Anderson's bone mill grinder
Bandages
Cast materials
Brace
Corset
Cushions
Sandbags

Routine Technic of Operations of the Back

Sequence of Steps in Operative Procedures

1 Preparation
2 Posture of patient on operating table
3 Anesthesia
4 Operating room preparation of patient
5 Skin—preparation—scrubbing—local antiseptics
6 Draping
7 Incision
8 Isolation of wound
9 Dissection
10 Control of hemorrhage
11 Sponges moist—soft—cotton
12 Special preparations
13 Blood and blood substitutes
14 Sutures deep—superficial
15 Dressings—compression
16 Immobilization—cast or brace or binder
17 Post operative care
18 Posture in bed
19 What to look for
20 What to guard against
21 What to do about it

3 Is the operation attended by unusual risk in the general run of people?

4 Is the operation attended by any unusual risk in this particular person?

The success of any operation on the back is contingent upon the surgeon's possession of full knowledge of the anatomical structures within and without the spine and their functions in relation to the rest of the body

During surgery one should investigate all structures possibly by *direct* inspection A good rule is *Never cut anything you cannot see*

Operative Procedures on the Back Include

Injection	Arthrodesis—fusion
Manipulation	Reduction of fractures
Incision	Reduction of dislocations
Exploration	Bursectomy
Releases	Facetectomy
Laminectomy	Foraminotomy
Unroofing foramen	Osteotomy
Uncapping a nerve	

There Is General Agreement on the Fundamental Principles Such as

1 The selection of technical procedure must be correct
2 The exposure should be ample to inspect the pathologic changes within the spine
3 The most careful attention should be given to the avoidance of surgical trauma
4 All co existent lesions should be noted and if possible treated
5 Hemostasis should be complete

Instruments Apparatus and Accessories for Spine Operations

Instruments	*Accessories*
Rongeurs	Bone wax
Lewin rongeur	Oxycel
Osteotomes	Fibrin foam gel foam
Chisels	Cellulose gauze
Periosteal dissector	Electric coagulator
Curettes	Suction apparatus aspirator
Drills	Irrigation apparatus
Bone clamps	Blood
Bone saws -Luck	Plasma
Retractors	X ray view box
Pituitary rongeurs	Kerrison s rongeurs
Spurling pituitary punch	Beaver knife and DeBakey blade

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SURGICAL ARMAMENTARIUM

The proper armamentarium is imperative It is the responsibility of the surgeon

Transfusions for fluid balance and blood and electrolyte replacement are very valuable

Proteins —It is important to supply amino acids These may be natural or synthetic They may be given by mouth, by vein, by tube, or by rectum

Preoperative Metabolic and Biologic Preparation—Chemistry—Nutrition—Protective Measures —In the preoperative dietary measures proteins and carbohydrates are desirable but fats are not The patient should increase the carbohydrate content of his food several days before operation Fruit juices, sweetened with dextrose, should be taken freely, honey may be eaten with meals, ice cream and ices are helpful, lemon stick candy may be eaten after meals

A coagulation time test should be made on every patient and his blood type should be determined Every person who is to be subjected to an extensive back operation should have from 250 to 500 cc of plasma or blood beforehand

Preparation of Surgeon's Hands for Surgery of the Back —The scrub brush is still advocated for the first scrub of the day since it aids in the mechanical removal of street dirt and desquamating epithelium A four-minute hand preparation using an antiseptic compound has been found sufficient The most successful of the compounds used to date is hexachlorophene (G-11) in either 2 or 3 per cent concentration

Operating Tables —The proper position of the patient on the operating table saves much time and energy and minimizes lost motion

The position of the surgeon assistants and nurses are important All cushions and frames must be in order The nurses operating room tables must be located properly and have the proper contents

ANESTHESIA

The anesthetist is an important person in all operations but especially in prolonged or shocking or bloody procedures and where there is much pounding chiselling or sawing The wise surgeon never fails to observe the anesthetist's warnings The experienced surgeon always takes occasion to ask 'How is she doing?' or 'What is her blood pressure?'

Local Anesthesia —The indications for local anesthesia are chiefly the contraindications to general anesthesia The solution used is a 1 or 2 per cent solution of procaine hydrochloride containing 4 minims of adrenalin to the ounce As much as 100 cc may be injected safely but usually one-half or one-third of this amount is sufficient

Relaxation of the muscles may be complete

Supplementary medication is helpful

Paravertebral Anesthesia —The thoracic nerves after emerging from their foramina connect by means of the rami communicantes with the sympathetic chain, after which they make their division From above downward one may contact the intercostal nerve a short distance from the

lateral vertebral border by introducing the needle just below the corresponding rib. As the needle point passes the border of the rib, it may be advanced from 0.5 to 1 cm., and a few cubic centimeters of the solution introduced, the needle being advanced and retracted continuously. In the lumbar region the transverse process of the vertebra may be used as a guide.

The needle should be inserted 2 to 3 cm. laterally from the midline until the vertebral arch is touched. It is then passed between the two transverse processes 1 to 2 cm. deeper, where it encounters the nerves as they emerge from the spinal foramina. It may be more practical to introduce the needle somewhat farther from the midline and make an infiltration using 15 cc. of a 0.5 to 1 per cent novocaine-adrenalin solution. The angle at which the needle should be introduced is about 120 degrees. Paravertebral anesthesia requires the introduction of from 200 to 400 cc. of the solution.

Spinal Anesthesia.—The chief indications for spinal anesthesia are senility, cardiac degeneration, renal degeneration and pulmonary conditions. The solutions used are procaine, spinocaine and nupercaine. After the spinal puncture has been performed and the injection made, the patient is placed on his side or back in a reclining position so that his head is 15 degrees lower than his body. The induction of complete anesthesia requires about twenty minutes.

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CHAPTER 15

SURGICAL CONSIDERATIONS IN OPERATIONS ON THE BACK

Asepsis — Asepsis is the foundation of spine surgery

Pre-operative Care — The patient should begin by increasing the carbohydrate content of his food several days before the operation Fruit juices sweetened with cane sugar or powdered dextrose should be taken freely honey may be eaten with meals, ice cream and ices are advisable and lemon stick candy may be eaten after meals A blood coagulation time test should be made on every patient and his type determined

In the Operating Room —Speed in operating comes first from knowledge but chiefly from experience and practice Gentleness in the handling of the patient and his tissues is of extreme importance The interne must see that the nurses and everyone entering the room observe all the rules of asepsis Instruments must be covered at all times The "no touch" "knife and fork" or Lane technic must be strictly practiced The most important factors in causing infection are (1) the patient's skin, (2) the skin of the operator and his assistants including the nurse, (3) the preparation by the nurse including instruments (4) sterilization of instruments and sutures (5) traumatization of the tissues and (6) loss of blood

The interne must know how to adjust the standard types of operating fracture and orthopedic tables A supply of sandbags must be on hand

Preparation of Area to be Operated On —Surgical procedures on the spine require the strictest pre-operative preparation The routine consists of thorough shaving and cleansing with benzine followed by scrubbing with green soap and water and the application of alcohol ether and sterile dressings

Preparation of Surgeon – The preparation of the surgeon, assistants and nurse must be faultless

Position of the Patient on the Operating Table — The assistant should provide for the various positions of the patient on the operating table which facilitate ease of operation Spine operations usually are performed while the patient is lying prone In performing some of the operations on the lower part of the back or coccyx it is of advantage to place the patient on his face with the foot of the table dropped so that the buttocks are elevated and the legs dependent Sandbags and cushions are used to maintain the patient in the optimum position An outrigger consisting of a rest for the chin and forehead is useful in back and neck operations Foam rubber cushions are now in general use to minimize interference with respiration

Draping the Patient —The technic of draping a patient is important Every patient should wear a perineal shield

Isolation and Protection of Wound —Towel clips are generally used Skin clips of the Michel type are in favor at certain clinics The skin-

clip method excludes the skin edges as a source of infection during operations When the skin is incised a towel is placed over the wound and while the assistant grasps the towel and one skin edge with two toothed forceps clips are applied and the towel is turned back The other skin edge is treated similarly Clips are then placed in the corners of the wound and on the two edges of the towel at both ends Some surgeons prefer to suture the towels to the edges of the incision

The true surgeon always avoids any needless trauma The use of powerful mechanical retractors, the neglect of hemostasis the unnecessary bruising of tissues and traction on them, are to be deprecated Retractors should be employed with as little force and trauma to the tissues as possible Hemostasis applied to blood vessels must not injure tissues around the vessel Tissue crushed by clamps or traumatized by rough retracting may jeopardize a good result

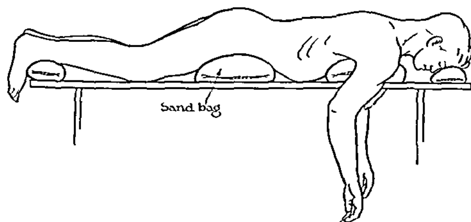


FIG 70 —Position of patient on table in preparation for operations on the spine

Ligation of Vessels —Large vessels must be ligated In ligating one should avoid grasping too much tissue

Electrohemostasis —There is a growing tendency in some clinics to use electric coagulation instead of ligatures

Suture Material —Standard sutures and ligatures and their technic of application are employed

Infection may be due to contamination by the operator, his assistants or others *who handle the instruments suture material and sponges*

Placement of Sutures —Skill is necessary in the placing of sutures in order properly to approximate the tissues without strangling them which would result in necrosis and giving way of the suture line The simpler methods of suturing are not only easier and quicker but also approximate the tissues accurately with better prospects of proper wound healing and they are less likely to result in bleeding and necrosis

Drainage —Drainage of the wound is strictly avoided if possible

Dressings —Collodion dressing is especially indicated in any operative field that is exposed to external contamination Some surgeons use Aeroplast Cellophane is used as a covering of dressings in some clinics For

those surgeons who prefer rigid post-operative support, a previously prepared plaster shell saves much time and minimizes shock

Surgical Shock —Surgical shock is characterized by persistently reduced arterial pressure by a rapid thready pulse, by pallid grayish or slightly cyanotic skin cold and moist with perspiration, and by a superficial rapid respiration Much of the shock experienced by patients from wounds and operations is due to hemorrhage Shock can be minimized in operations on the spine by avoiding undue pounding with hammer and chisel

If a blood transfusion is indicated it should be given early Venoclysis should be started as soon as the incision is made

Shock resulting from injury was divided into two types by Blalock, Beard and Johnson (1) primary shock in which low blood pressure follows immediately and (2) secondary shock in which at least an hour usually elapses between the time of injury and the development of low blood pressure

Many theories have been offered in an effort to explain the mechanism of the production of secondary shock These include the theories of (1) vasomotor exhaustion (2) inhibition (3) fat embolism (4) acidosis (5) suprarenal disturbances (6) toxemia

Hemorrhage complicating operation accident or disease may cause early and rapid circulatory failure

Dehydration is caused by excessive output of fluid insufficient intake of fluid or a combination of these

Venoclysis —Venoclysis provides for the continuous administration of physiological and therapeutic solutions directly into the blood stream The rate of flow is regulated so that it will enter the blood stream in accordance with an estimated rate of delivery and distribution Clinical experience indicates that for adults this rate is approximately 200 cc of fluid an hour or a range of between 4000 and 5000 cc of fluid in twenty-four hours

Dextrose Glucose —The chief food that can be administered intravenously is sugar Fat cannot be used because of the danger of fat embolism foreign protein is dangerous because of the reaction Dextrose is most commonly used because it is normally found in the blood Amino acids are favored by some

Transfusion.— Blood transfusion should be a routine procedure during extensive spinal operations along with glucose or saline or serum for the maintenance of blood volume and reduction of morbidity and mortality Whole blood substitutes used frequently are plasma and gelatin solutions

If sufficient loss of blood is anticipated to jeopardize life or delay progress a pre-operative transfusion is of great value If the operation has been performed and the patient has lost considerable blood, transfusion is indicated

Blood Plasma —Blood plasma is now considered more efficacious than whole blood in the treatment of surgical shock by transfusion particularly in military surgery and in cases of hematogenic or delayed shock In neurogenic or primary shock there is no loss of blood volume therefore whole blood is still to be preferred Plasma or serum transfusions are also recommended in shock due to burns

Irradiation of Plasma.—Wolf, using apparatus devised by Oppenheimer and Levinson, has shown that plasma can be irradiated without significant alteration of the proteins and can be safely administered to patients. Blanchard and others have shown that irradiation of plasma is effective in preventing transmission of homologous serum jaundice.

Intratibial Infusion of Saline and Glucose.—Massey administers fluids into the bone marrow of a child's tibia when other routes of administration are unavailable for technical reasons.

EMERGENCIES

The chief emergencies in back cases are crushing wounds, and such severe injuries to the spine as fractures with or without dislocation.

Post-operative thrombosis and embolism are serious complications but are not always fatal. Blood-stream infections after spine operations are rare.

POSTOPERATIVE CARE

In the postoperative care one observes the return of the patient to his bed, his placement in bed and his posture in bed and his comfort. One must beware of twists of his neck.

Medication is prescribed.

Blood and blood substitutes are provided.

Danger signals are observed, especially pain and hemorrhage and impending embolism.

In a male patient, catheterization calls for the services of an urologist.

Directions to the nurse must be explicit.

After the operation, the patient is placed in bed in the lateral position on pillows, to prevent undue pressure on the tips of the shoulders and on the hips. It is preferable to turn him from side to side and on his abdomen rather than to allow him to lie on his back, because perspiration may result in maceration of the skin and contamination of the incision, and may interfere with primary union.

those surgeons who prefer rigid post operative support, a previously prepared plaster shell saves much time and minimizes shock

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expedite the surgical procedure. Methods of isolating the wound against gross contamination include varnish, skin clips and plastic drapes.

Draping of an extremity or iliac area if a graft is to be taken must be carried out meticulously. Bicycle "pants guards" are useful in securing the linen around the leg just above the ankle when a tibial graft is to be removed.

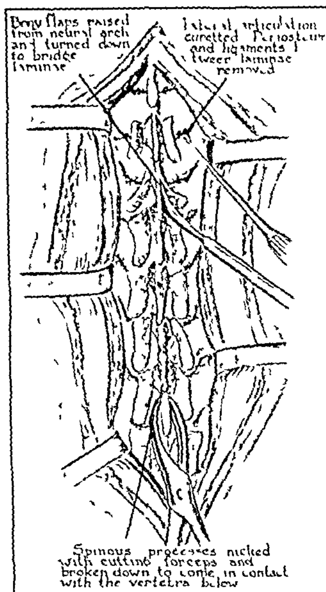


Fig. 71.—Hibbs spinal fusion operation. (Steindler: *Orthopedic Operations*, courtesy of Charles C Thomas.)

Bone Grafting.—The basic procedure is deskeletalization of those vertebrae to be fused. Several modifications of the procedure have been proposed.

Cancellous Bone Grafts.—Many patients complain of the discomfort in the region of the ilium when iliac bone is used. Pike and Larrabee employ a very useful method of taking iliac bone described by Robertson and Barron. They decorticate the bone, use the medulla and suture the cortex

CHAPTER 16

OPERATIVE PROCEDURES AND TECHNIC

The types of operations for back disorders are described as release, decompression and fusion procedures. The operative technic must be as atraumatic as possible.

Postoperative care includes relief from pain, adequate sleep, proper diet and good nursing. The Stryker frame is a valuable aid. The matter of water balance is of paramount importance. The causes, prevention, recognition and treatment of shock must be constantly in mind. The value of blood plasma and serum is proved. Large amounts of vitamin C should be administered soon after operation.

The various operations that are performed on the spine are aimed chiefly at decompression and stabilization. The two chief types of stabilization operations are the bone-graft and the fusion procedures. The most common operations are of the Albee, the Hibbs and the Delagenière-Lewin types.

Hadra in 1891 wired the vertebral spinous processes. Lange placed metal rods and later celluloid splints beneath the muscles on both sides of the spinous processes to hasten ankylosis. He also suggested transplantation of bone for the same purpose. Calot in 1897 employed a technic which was aimed at fusion of the vertebra.

Operative Technic.—Spine operations should be performed under the strictest aseptic technic. No fingers should be allowed to touch the wound or skin. Only the "working ends" of the instruments should come in contact with the wound, and no instruments that touch the skin should be allowed to touch the inside of the wound. All knots must be tied with forceps.

Surgical Approaches to the Spine.—A knowledge of bony landmarks, blood supply and nerve routes forms the basis of all surgical approaches. In all operations on the spine and leg the incision and route of approach should be aimed at the conservation of circulation. Incisions should avoid sinuses and fistulous tracts even if they are to be excised. A liberal incision gives adequate view and thereby avoids delay, gives access to anatomical structures, and avoids the trauma of pulling, tearing and using undue force on retractors.

Adequate exposure of the tissues to be operated on is the most important technical step. The field must be brought into view so that the operation can be carried out accurately and without undue trauma to neighboring tissue. Insufficient exposure predisposes to trauma and hemorrhage.

Surgical Technic.—The optimal exposure and approach are very important to the surgeon and patient. The proper incision, isolation of wound, and the careful selection and utilization of appropriate retractors

expedite the surgical procedure. Methods of isolating the wound against gross contamination include varnish, skin clips and plastic drapes.

Draping of an extremity or iliac area if a graft is to be taken must be carried out meticulously. Bicycle "pants guards" are useful in securing the linen around the leg just above the ankle when a tibial graft is to be removed.

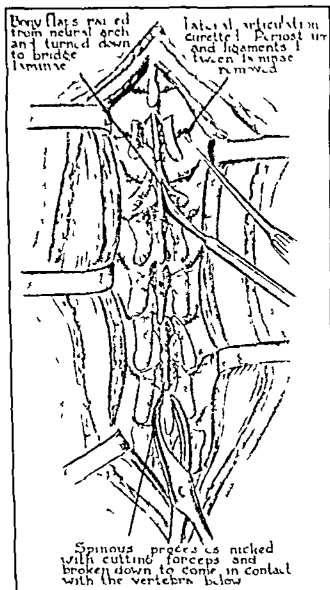


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Bone Grafting.—The basic procedure is deskeletalization of those vertebrae to be fused. Several modifications of the procedure have been proposed.

Cancellous Bone Grafts.—Many patients complain of the discomfort in the region of the ilium when iliac bone is used. Pike and Larrabee employ a very useful method of taking iliac bone described by Robertson and Barron. They decorticate the bone, use the medulla and suture the cortex

The patients have practically no pain postoperatively and they are left with a minimum of deformity as a result of the removal of the bone

The patient's ilium is the best bone bank for every purpose except splinting

Anderson uses a bone paste like soldering lead

Bone crumbs are often better than chips

Bone fragments that look like the cereal "Grapenuts" provide greater area of bone contact Vascularization and circulation are favorable It is like pouring molten bone into the interspaces

Bone chips or crumbs act like blotting paper, absorbing blood which is vital to consolidation of bone

Bone Graft Surgery of the Spine

Operations on the vertebrae are known by the names of *Hibbs* spine fusion Albee massive graft from the tibia Delagenière-Lewin Gaenslen Campbell Mercer and Cloward

The two methods most commonly used now are the extra articular arthrodesis with inlay tibial graft first described by Albee and the intra-articular fusion of Hibbs The former operation obtains splintage of the spinous processes by the tibial graft

Bone grafting is done to provide a framework of bone, to add strength and to stimulate osteogenesis Bone grafts may be made of living or dead bone and may be autogenous homogenous or heterogenous The human bone graft is usually taken from the patient's tibia ilium or ribs The graft should be made in relation to strength from bone as porous as the requirements of the patient will allow

Gibson recommended a modified graft for spinal fusion which is illustrated *in Figure 74 He called it a fishtail graft Bosworth* described it independently as the clothespin graft Moore and Cook designed similar grafts

Taylor devised the operation of hemilaminectomy It may be combined with hemifusion that is a laminectomy on one side of the spine and a fusion on the other

Campbell performed fusion operations on the spine by the transplantation of a portion of the crest of the ilium into the spinous processes, after the manner of Albee *The crest of the ilium conforms to the normal lumbar* lordosis in this region

Haggard recommended securing additional bone from the posterior superior iliac spine which can be exposed through the incision made for lumbar fusion swung slightly to the side from which the bone is to be taken *The fragmentation will extend the surface area exposed and thereby increase* the number of surviving osteoblasts Bone dust helps consolidation Tricalcium phosphate powder is used by some authorities as a local agent to help build up solid bone

The Delagenière-Lewin operation is a combination of Hibbs' operation and the osteoperiosteal graft *Fusion of the articular facets, which combines* the Hibbs' technic with an osteoperiosteal graft from the tibia is a valuable aid, no matter what type of operation is performed

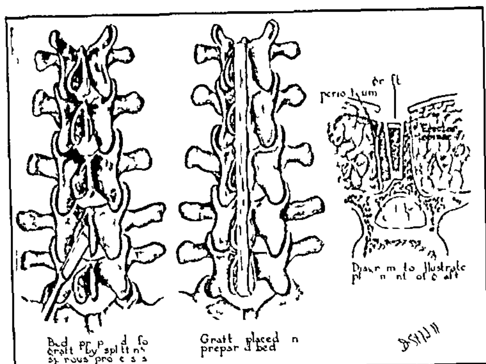


Fig 72 — Albee's spinal fusion operation (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

Fig 73 — Spinal fusion operation Combined method of Steindler (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

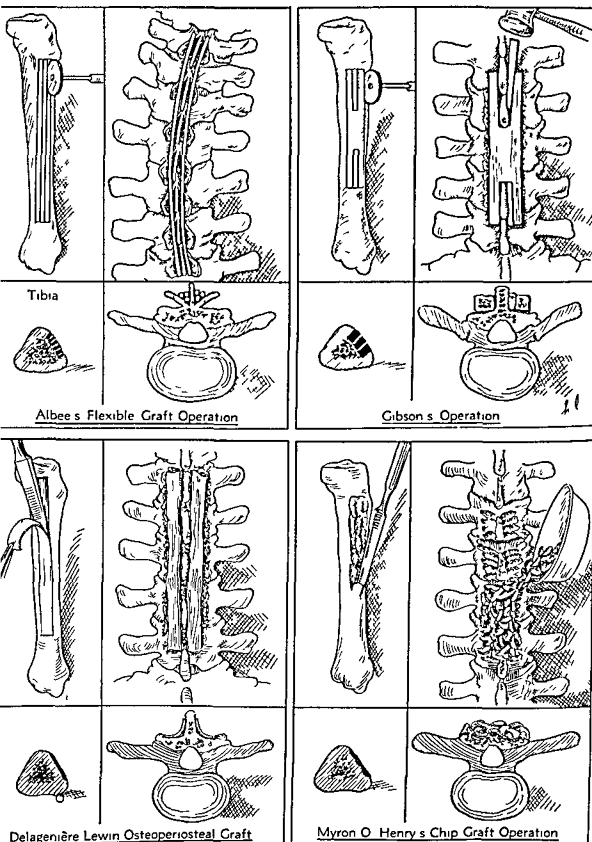


Fig 74 —Various types of standard operations on the vertebræ

Albee Tibial Graft —Albee uses two methods almost exclusively—the single-graft inlay and the bent-shingle method, or the "bundle of reeds" The exposure and preparation of the spinal gutter, or graft bed, is the same in all cases Using a broad thin osteotome the spinous processes of the affected vertebræ and of two above and two below in the thoracic region (only one above and below in the lumbar region) are split *in situ* in halves longitudinally, almost down to the neural arches After one process has been split, he anchors one edge of the osteotome in the cleft so as to guide the other edge while it splits the next process above or below Care must be taken to fracture only one-half of each spinous process

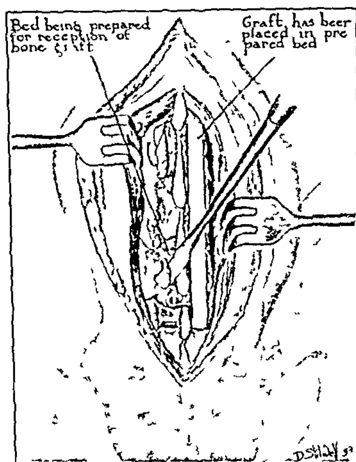


FIG 75 —Lumbosacral fusion Combined method of Steindler (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

The gutter for the graft must be bounded by a row of fractured half-spines on one side and a row of unfractured half-spines on the other The single graft from the tibia must be long enough to cover the entire length of the gutter It must be strong enough to stand the strain to which it will be subjected, and its diameter should be one-fifth that of the tibia This flexible graft is then placed edgewise in the spinal gutter It is held there with kangaroo sutures through the split supraspinous ligament A thin strip of bone ¾ inch long, taken from the side of the gutter in the tibia, is placed transversely over the tip end of the graft and under the supraspinous or interspinous ligament, in close approximation to the

two halves of the spinous process, which are stripped of periosteum and recessed to receive it Having been firmly fixed at one end the graft is now grasped in a clamp and bent into the gutter and held with interrupted sutures of kangaroo tendon as the molding progresses The extreme end is held with a transverse locking graft of bone, such as was used to fix the first end This cross graft prevents the end of the graft from springing posteriorly out of the gutter

Before taking either a massive or an osteoperiosteal graft from the leg a constrictor should be applied to the mid thigh region Before a massive graft is taken from a tibia in patients past forty years, it is advisable to have an elastic stocking fitted before the operation, to be applied as soon as the dressings are small enough to put it on An Unna's paste boot may be used

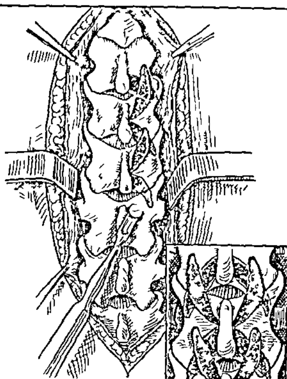
Hibbs' Spine-Fusion Operation — The technic of the Hibbs' spine-fusion operation taken practically verbatim from Hibbs' article is as follows After making the skin incision the tips of the spinous processes of the vertebræ to be fused are exposed The periosteum over the tips of these processes is split longitudinally and, with a periosteal elevator, pushed to either side, leaving the bony processes bare The periosteum and interspinous ligament are split still further and pushed forward a short distance from each spinous process as two lateral halves gauze packs being inserted to prevent oozing The dissection is continued until the spinous processes the posterior surfaces of the laminæ and the bases of the transverse processes are completely bared thereby exposing the ligamentum subflavum attached to the margins of the laminæ and the articulations of the lateral processes

The dissection may be made in a practically dry field, without injury to the muscles if it is subperiosteal and if free use is made of gauze packs Not only the baring of the bones must be complete but the periosteum may be separated from them in a practically unbroken sheet and without disturbance of its relation to the surrounding tissues and blood supply The greatest care should be exercised in this dissection After the bones are bared they may be treated in any manner which establishes their intimate contact and stimulates bone formation The ligament is removed from the laminæ with a curette and the articular surfaces of the lateral processes are destroyed in order to establish bone contact at this point With a bone gouge a substantial piece of bone half the thickness and width of the lamina is elevated from the adjacent edges of each lamina The free end of the piece from above is turned down to make contact with the elevated edge of the lamina below

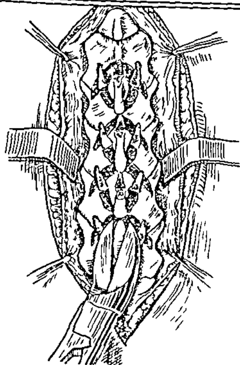
Each spinous process is then partially divided with bone forceps and broken down, forcing the tip to come into contact with the bare bone of the vertebra below The spinous processes of the last vertebra below should be turned up to contact the next above As the spinous processes of the lumbar region are wide, it is sometimes practicable to split them, turning one-half up and the other half down Thus contact of abundant cancellous bone is established at the articulation of the lateral processes, laminæ and spinous processes (Briggs adds chip grafts and interspinous bone plugs)



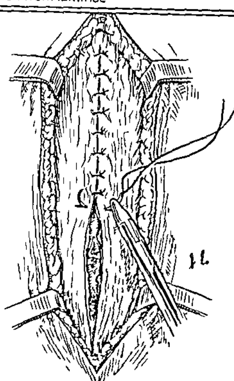
Exposure of spinous processes by incision through ligament and periosteum



Periosteum dissected from spinous processes and laminae Ligamenta subflava and articulations curetted Bone elevated from laminae



Spinous processes partially fractured and turned down to make contact



Periosteum and ligament closed by interrupted sutures of chromic catgut

Fig 76 —The technic of the Hibbs operation for spine fusion

The unbroken sheets of periosteum and ligament, which together have been pushed to either side, are brought together in the middle with interrupted sutures of ten-day chromic catgut. With the closure of the periosteum, what is practically a tube of periosteum is formed, with its abundant blood supply undisturbed, filled with healthy, living cancellous bone lying in continuous contact.

The subcutaneous tissue is then closed with a continuous suture of plain catgut, the skin wound is closed with sutures of ten-day chromic catgut, and sterile dressings and an immobilizing brace or plaster are applied. This operation insures fusion of the lateral processes, the laminæ and the spinous processes. The fusion should include at least one healthy vertebra above and one below the injured vertebra.

The extent of fusion in each case varies with the extent of the lesion and, as a general rule, should extend from the neutral vertebra above to the neutral vertebra below the lesion. This situation is consistent with the physiological laws of bone growth; it furnishes a stimulus to their operation and insures a fusion of the lateral processes, the laminæ and the spinous processes.

Usually no immediate post-operative support is applied, the patient being placed in a bed without springs.

Laminectomy.—Laminectomy means the cutting away of the spinous processes and laminæ to expose the spinal cord or its meninges. The conditions for which laminectomy may be required are: (1) fractures and dislocations of the vertebræ; (2) inflammatory processes, meningitis and abscess; (3) compressions of the spinal cord; (4) spasticities due to inflammatory diseases, cerebral birth palsies or old injuries; (5) spinal cord tumors; (6) relief from intractable pain; (7) congenital defects such as spina bifida; (8) protruded intervertebral disks.

Preparation.—The preparation for laminectomy includes local measures and those employed before any major orthopedic operation. Roentgenograms should be checked and rechecked accurately to localize the bony landmarks. Fluids should be given freely before the operation, and if there is any indication, blood transfusion should be performed. The position of the patient on the table is important and varies with the section of the spine to be operated on. For the cervical region an outrigger is used. For the lumbar region the patient should be on a table that can be raised in the middle. Cushions and sandbags permit the patient to be placed in the optimum position for exposure of the parts to be operated on and to prevent respiratory embarrassment and abdominal pressure. The landmarks should be determined by counting from above and below, using the spinous process of the 7th cervical vertebra, the lower margin of the scapula, the last rib and the line joining the crests of the two ilia. One must determine the number of vertebræ to be exposed and should make the exposure adequate.

The spinal cord is much enlarged in the cervical and lumbar regions. In the removal of the laminæ in these regions, special care must be taken that the cord is not injured.

Technic.—A midline incision is made over the spinous processes to be removed, and the dissection is made according to Hibbs' technic. It is

essential to keep in the subperiosteal plane With a large rongeur, the spinous processes are bitten off at their bases and by a tedious process of morcellation all bone is removed as far laterally as the articular processes Great care must be taken not to injure the dura When the removal of bone is completed the cavity is packed with sponges wrung out of hot water, in order to control the oozing from the bone

Remarks —Fluids may be given during the operation The greatest gentleness must be used in handling the spinal cord A slip of a rongeur may prove disastrous Slight trauma to the cord may cause permanent disability It is important to avoid opening the dura unless necessary, because this increases the mortality The exposure should be liberal

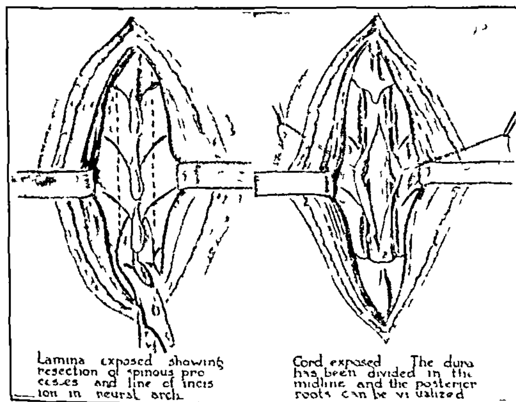


Fig 77 —Laminectomy (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

usually at least three vertebrae have to be exposed and often five six or seven laminae have to be removed

The functions of the vertebral column are almost fully recovered within six months after the complete removal of the spinous processes and laminae of several vertebrae

Occasionally the indications are for exploration of the spinal cord and fusion of the spine, which can be accomplished by a hemilaminectomy plus a hemifusion at the same operation The anesthetist must always see that normal respiration is not inhibited In operations in the cervical region he must also be careful that the neck of the patient is not compressed by the edge of the table or the outrigger

Laminectomy for Bone Tumor — At the Mayo Clinic the surgeons make sure of the site of the lesion before they perform a laminectomy During

the procedure one should bear in mind that the lesion must have been localized by roentgenograms. The spinal cord levels are situated above the corresponding osseous segments.

Subperiosteal elevation of the muscles will insure less bleeding than lateral reflection of the erector spinae muscles by sharp dissection. The laminae should be removed from the tumor with great care in order to avoid additional trauma to the cord. The surgeon also should have in mind that dural pulsations will be detected above the tumor but will be absent below it, since this observation will direct him in extending the laminectomy in the proper direction in order to expose and remove the growth properly.

Thoracic Laminectomy.—For laminectomy in the thoracic and lumbar regions both laminae and the spinous processes of from two to three vertebrae usually are removed. However, it frequently becomes necessary to extend the laminectomy for longer distances for removal of ependymomas of the filum terminale or neurofibromas of the caudal fibers. In order to eliminate any bony prominences, the tips of the spines in immediate approximation above and below the site of laminectomy are also removed.

Foraminotomy.—Ghormley and Briggs and Krause have described this procedure. The intervertebral foramen is a bone-lined duct, the dimensions of which are only slightly altered under normal conditions. Any encroachment upon this space will result in pressure upon the soft tissues contained within it.

Three indications for an intervertebral foraminotomy are: (1) when laminectomy with complete exploration of the accessible nerve root within the neural canal has failed to reveal an impinging mass; (2) collapse of an intervertebral disk space with or without hypertrophic lipping is seen on the roentgenogram; (3) previous spine surgery which has failed to relieve sciatic pain.

A closed canal is converted into an open trough. In order to open the intervertebral foramen, the facets with their articular processes are removed. Sufficient bone, ligamentum flavum and capsule are removed to visualize the nerve root along its entire course until it passes into soft tissue. The lesion is removed, operation is completed by placing a small piece of muscle tissue over the exposed nerve root, and fusion is performed.

The various *types of fusion operations* include basic procedures and modifications thereof. The basic procedures are the Albee and the Hibbs technics. Many modifications have been proposed by various surgeons.

Lumbosacral Fusion by the Hibbs Technic.—Smith insists that the first requisite for any spine fusion operation is a painstaking, clean dissection of the ligament, periosteum and muscles from the bone. This should be done with a minimum of bleeding.

In a lumbosacral fusion of the Hibbs type, a midline incision is made from the spinous process of the vertebra above the area of the fusion to the third sacral spine. The dissection then includes the spine and a portion of the laminae. The ligaments with the periosteum are separated from the spines and laminae with a sharp elevator. Before stripping to any depth it is best to expose the tips of several spines and to proceed in length as well as depth. Before the upper arches are exposed completely, the lumbosacral joint should be identified.

The muscles are retracted and the capsular ligaments of the lateral articulations are detached with a chisel elevator and retracted laterally. These ligaments are then incised at the outer sides of the joints and are removed with a curette.

Starting just medial to these joints, the superficial portion of the ligamenta flava are then detached from the upper margins of the lower laminae and excised with a curette. The deeper layers of these ligaments should not be removed, however, unless the intervertebral disks and nerve roots are to be explored.

The next step is the removal of the cartilage from the articulations. It is Smith's practice to detach the cartilage with the blade of an angled osteotome. *It is desirable not to make the space left by removal of the cartilage any wider than is necessary.* The cartilage then is removed with a curette. An angled curette is helpful in reaching the depth of the joint. Thorough removal of the cartilage is most important. After the cartilage has been removed, the space between the facets should be narrowed.

Several cuts are made with a thin osteotome into the articular processes parallel with the joint surfaces so that these thin slices of bone fill the spaces. The inclusion of the lateral articulations in the fusion is of great importance.

The next step is to bridge the spaces between the laminae and spines. With a gouge, several small pieces of bone are turned up from the fossa just below the articulation over the joint. Longer strips are then turned up from the lower lamina and down from the upper one so that they interlock. It is advisable to keep these pieces of bone attached at their bases because it prevents them from becoming displaced. The spinous processes may be left intact and the strips of bone are started from their tips. Smith cuts off the tips of the spines, splits them into smaller pieces, and uses them to reinforce the fusion.

Usually an adequate amount of bone can be turned up from the sacrum. If this bone will not suffice or if the fourth lumbar is to be added, more bone may be placed on the bed already prepared. The best source is the posterior part of the ilium. The cancellous bone from this area is ideal and long strips cut from the crest and outer side of the ilium may be used to bridge the entire length of the fusion. An easy exposure is gained by a separate curved incision over the posterior crest. The bleeding from the ilium after removal of the grafts may call for the use of bone wax or oxycel gauze.

If a bone bank is available, the operation is shortened. Strips of ribs or pieces of cancellous bone from the ilium are the best.

Internal fixation by metal increases the stability of the spine during the early stages of repair after a fusion operation. King and Von Lackum placed screws through the lateral articular processes. This produces excellent fixation of the fifth lumbar vertebra to the sacrum, where a long screw of from 1¼ to 1½ inches in length can be made to penetrate the lateral mass of the sacrum and thus have a good purchase. A drill is driven from the inner side of the upper facet downward and outward through the sacral facet and into the lateral mass. The drill is then withdrawn and the screw introduced along its track. *It is Smith's practice to use screws in those cases in which the fifth lumbar is quite mobile and unstable.* They are particularly helpful in spondylolisthesis, in which the fifth lumbar arch is

FIG 78 — A Showing the denuding and roughening of the spines and laminae with a curved osteotome B and C show the overlapping strips of iliac bone laid in position D shows the manner of obtaining the iliac strip (Michele and Harper courtesy of Military Surgeon)

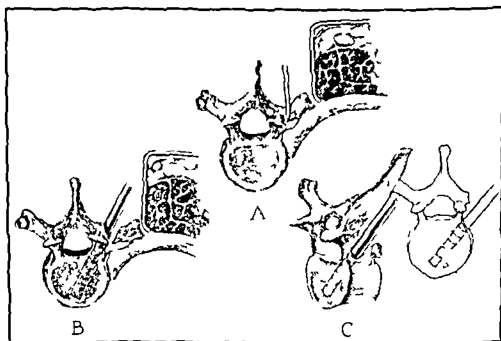


FIG 79 — A Transverse osteotomy at the base of the thoracic transverse process B Trephine through the fenestra of the isthmus into the pedicle and body C Trephine inserted into the body at junction of pedicle (Michele and Krueger courtesy of J Bone & Joint Surg)

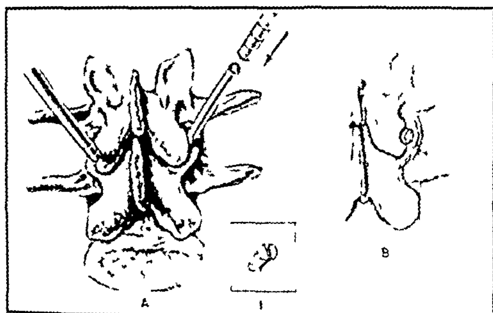


Fig 80 — A Marker is inserted into the articular facet Trephine is slipped over the marker B The bored leaves of the articular facet with a channel [illegible] I Inset shows the two buttons of bone removed (Michele and Krueger courtesy of J Bone & Joint Surg)

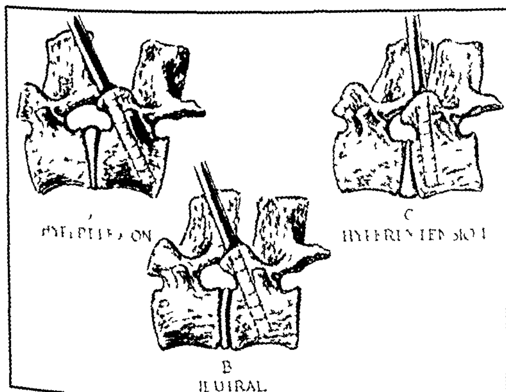


Fig 81 — The position of the spine on the operating table will determine the direction of the trephine (Michele and Krueger courtesy of J Bone & Joint Surg)

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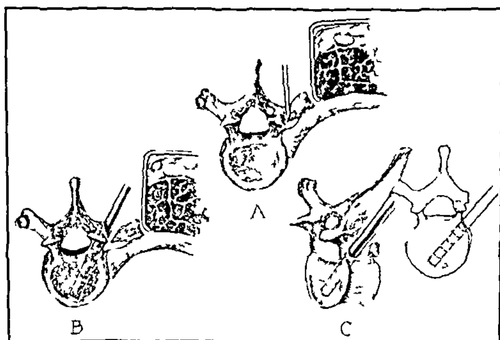


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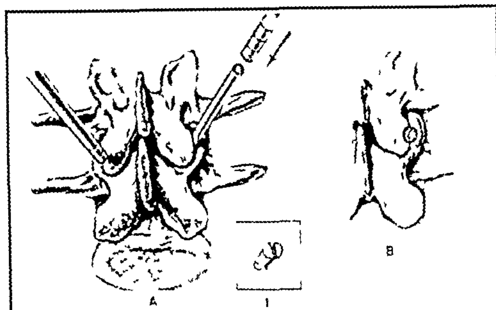


Fig. 80.—*A.* Marker is inserted into the articular facet. Trephine is slipped over the marker. *B.* The bored leaves of the articular facet with a channel of cancellous bone. *I.* Inset shows the two buttons of bone removed. (Michele and Krueger: courtesy of J. Bone & Joint Surg.)

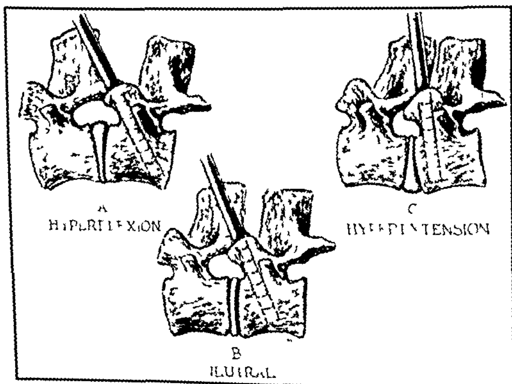


Fig. 81.—The position of the spine on the operating table will determine the direction of the trephine. (Michele and Krueger: courtesy of J. Bone & Joint Surg.)

quite loose. He does not use them when the fifth lumbar feels firm and is not easily movable, nor in the higher lumbar joints.

The operation is completed by approximating the tissues in layers with separate rows for the muscles, deep fascia, superficial fascia and skin. Interrupted silk sutures are followed by the best healing.

Smith places the patient immediately on a firm bed with a board under the mattress and does not use any external support as long as he remains in bed. The patient is turned as frequently as is necessary for his comfort and is taught to turn himself in bed as soon as he can do so. Smith allows his patients up from bed at the end of the second week. X-rays are then taken to show whether the bone chips and grafts are in position. The patient walks as soon as he is able, usually within a day to two after getting up, and is ready to leave the hospital at the end of the third week after the operation.

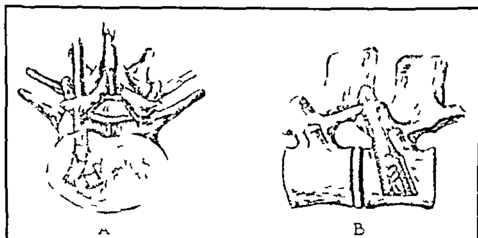


Fig. 82.—A, The curved trephine is used to indicate the circumference of penetration of the body by the curette. B, Iliac bone graft used to reinforce the articular facet is fixed into the pedicle. (*Michele and Krueger, courtesy of J. Bone & Joint Surg.*)

Some support is provided as soon as he gets out of bed and is worn until x-rays demonstrate that the fusion is well advanced, usually for about four months. The patient's activities are restricted and all bending or lifting and carrying heavy objects are prohibited until the fusion is strong. Heavy manual work and sports are not permitted until six months have elapsed.

The most common symptoms of failure of fusion are pain and fatigue.

The most accurate method of determining solid spinal fusion is by x-rays made in flexion and extension. When such x-rays are superimposed one can visualize any excursion at the fused area.

Michele and Harper accomplish spinal fusion by producing an arthrodesis of the small spinal articulations supplemented with iliac bone strips laid on the roughened laminae and spines. They use a trephine for drilling through the articulations and making a bone plug. They have developed an effective technic for obtaining and placing the iliac bone

By approaching the vertebral body directly through definite bone channels the selected portions of the vertebral body contents are made available for diagnosis and subsequent therapy. These methods are particularly valuable in those cases in which the lesion is confined to the vertebral body and no other sources of biopsy or culture material are available. Moreover the direct approach facilitates the introduction of penicillin, streptomycin or other medication into the vertebral body.

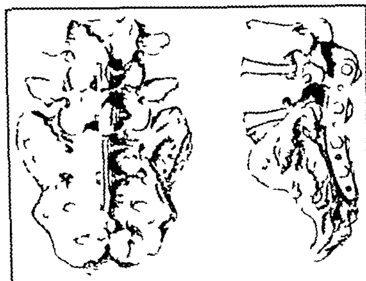


Fig. 83 — Model showing application of spine plate as done in the first two operations. The basic fusion technic is not illustrated. (Wilson and Straub, courtesy of Amer. Acad. Orthopedic Surgery.)

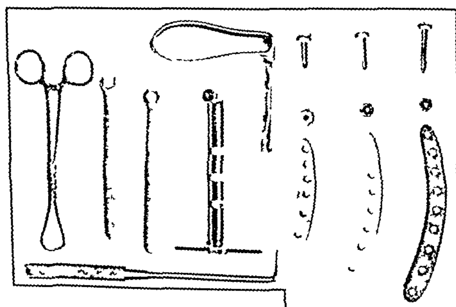


Fig. 84 Fig. 85

Fig. 84 — Instruments employed in application of spinal plate. Left to right: bolt holder for insertion of bolts, right angled geared socket wrench, end wrenches, Staude-Moore forceps, T and right angle awl. (Wilson and Straub, courtesy of Amer. Acad. Orthopedic Surgery.)

Fig. 85 — The spinal plates in three sizes with bolts, washers and elastic stop nuts with nylon inserts; all are vitallium. (Wilson and Straub, courtesy of Amer. Acad. Orthopedic Surgery.)

Prostheses have been devised by Lange, Wilson, Judet, Truchet, Straub and Sicard.

Wilson enumerated the objectives in the use of metallic internal fixation in lumbosacral spinal fusion as follows:

1. To provide absolute immobilization of the operated area during the period of osseous repair.
2. To shorten the period of postoperative recumbency.
3. To reduce postoperative discomfort, and
4. To reduce the number of fusion failures.

In addition to the routine Hibbs procedure plus bone chips from the tibia or ilium, Wilson places his plate on one side of the spinous processes and attaches it securely thereto with bolts and nuts, one bolt inserted through each lumbar spinous process and two bolts attaching the plate to the spinous processes of the sacrum.

In some cases additional fixation of the facets by screws are employed.

The solid-bone graft either from the patient's ilium or from the bank is shaped and drilled by an assistant. Holes are made to match those selected on the plate for best stability of the bolts in the patient's spinous processes. The holes in the graft are made larger than those of the plate to allow easy insertion of the bolt. Plate and graft are applied to opposite sides of the spinous processes and held in place with uterine tenaculum forceps passed through the holes of the graft and plate. These forceps start the holes in the spinous processes which are then completed with a right-angle awl. Insertion of the bolts in the narrow confines of the wound is facilitated by the use of a bolt holder which allows firm pressure along the axis of the bolt. After applying a washer on the bone-graft side, the nut is started on the bolt with a small right-angle socket wrench. Standard nuts are frequently loosened even though applied double or locked with wire. This was overcome by the development of a surgical elastic stop nut employing a nylon insert. These nuts allow secure fixation at any desired tension.

Metallic-plate fixation in lumbosacral spinal fusion is possible only if the sacral spinous processes are large enough to allow secure fixation by bolts. Small sacral spinous processes may be occasionally utilized by countersinking the plate if the posterior sacral wall is of sufficient thickness. The sacral spinous processes are adequate in about 75 to 80 per cent of the ordinary low-back patients. The purpose of the plate is to provide temporary immobilization and is not to be trusted unless it is demonstrably secure at operation.

Postoperative Management.—Compression dressings of elastoplast are employed. During the first twenty-four hour period following operation the patient is allowed to lie on either side or in the prone position. The blood soaked dressings are changed after 24 hours. This appears to be an important factor in avoiding decubiti. The head of the bed is elevated moderately when the patient is comfortable and desires it. When there is difficulty in voiding the patient is allowed to stand at the side of the bed from the first day on. At the eighth or ninth postoperative day the patient is allowed to sit on the side of the bed and then out of bed in the adjustable office type posture chair with arms. A high Goldthwait brace with subclavicular padded horns is applied on the tenth day. Ambulation is in-

creased as comfort and strength permit The brace support is continued for six months Patients are advised to limit their activities for three or six months depending on the nature of their occupation Simple postural exercises are started when the fusion is demonstrably solid

Crossed has replaced the bolts by tubular rivets He uses the following instruments a punch which perforates the base of the spinous processes Tubular rivets each with a flat head are passed through the graft, the spinous process and the plate and a crushing forceps which flattens the protruding portion of the rivet on the plate (like a grommet) This makes it possible to obtain with one rapid maneuver the same solid fixation as that provided by slowly screwing a nut on a bolt

Truchet used a Wilson vertebra plate combined with a bone graft bolted to the sides of the spinous processes Judet reported on the use of an acrylic prosthesis which bound the last three lumbar vertebrae to the posterior superior iliac spines This permitted early ambulation Sicard employed a similar procedure

Lumbosacral Arthrodesis by Means of an Ossacryl Prosthesis — The ossacryl prosthesis which Sicard favors for lumbosacral arthrodesis has a center which is comprised of a single slot into which there are partitions which are used for the ossacryl pegs for fixing the prosthesis in place The pegs are passed transversely through perforations in the spinous processes These pegs are passed alternately first from one side and then from the other thus wedging the prosthesis firmly in place

At the moment of application the midsection of the table is raised to place the spine of the patient in an exaggerated kyphosis so that when the prosthesis is properly fixed in place and the normal posture of the spine is resumed the whole prosthesis and spinous processes form an immovable unit

This technic has been employed by Sicard on 36 patients Two of the prostheses had to be removed five and six months later In the rest of the cases the prostheses have remained healed in

Osteoplastic Anterior Fusion of Lower Lumbar Spine in Spondylolisthesis, Localized Spondylosis and Tuberculous Spondylitis —Gjessing performed the operation transperitoneally according to Mercer s method in two cases whereas in the remaining seven he performed it extra-peritoneally through a paramedian incision He used one large bone graft which was trimmed to a wedge shape to fit into the corresponding groove chiseled out of the two vertebrae A Z-like incision was made in the anterior longitudinal ligament before chiseling out the groove for additional support of the graft The extraperitoneal approach involves less danger as it provides better exposure of the large vessels

EXTRA SPONDYLAR SOURCES OF BONE FOR SPINE FUSION

The present trend is away from tibial toward iliac bone of the patient or iliac bone from the patient and tibial bone from the bone bank Many surgeons have discarded the use of bank-bone in lumbosacral fusions, in favor of iliac bone grafts Abbott and Gill describe the ilium as having a body and an upper portion

Prostheses have been devised by Lange, Wilson, Judet, Truchet, Straub and Sicard.

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FIG 87 —*A B C D* Coronal sections from the anterior portion of the crest of the ilium showing the width of the bone and its cancellous structure Grafts are most frequently cut from this area *E F G* Horizontal sections of the posterior third of the crest Grafts taken from this area are used for fusion of the spine (Abbott and Gill Medico Surgical Tributes to Harold Brunn courtesy of Univ Calif Press)

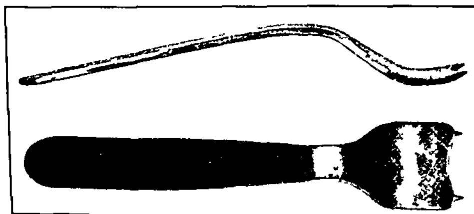


FIG 88 —Retractors specially designed for the removal of iliac grafts They are also very useful in many other operations (They are adapted from the Bennet retractor) (Abbott and Gill Medico-Surgical Tributes to Harold Brunn courtesy of Univ Calif Press)

or ala. The superior margin of the ala, which is roughened and thickened, is known as the iliac crest. Upon this crest are three rough lines produced by the attachment of the abdominal muscles. The crest is subcutaneous throughout its entire extent and is covered by a thick layer of periosteum. The ala is composed of thin inner and outer layers of cortical bone which enclose a central portion of cancellous bone. With the exception of the posterior third of the bone, the iliac crest is the widest part of the ala of the ilium. The widest portion is at the junction of the anterior and middle thirds, the narrowest portion being at the junction of the middle and posterior thirds. In this region it is composed only of the inner and outer

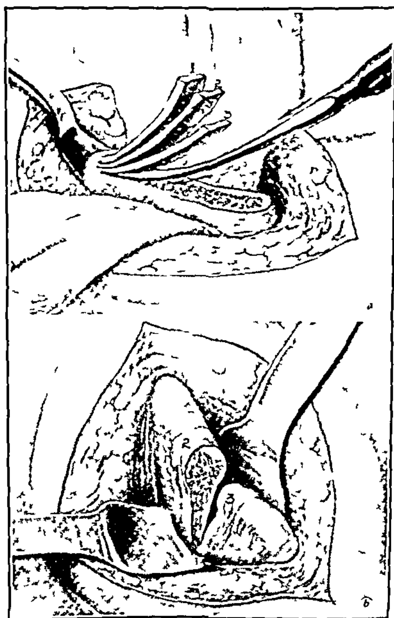


Fig 86.—*a* The method of removal of the slide or chip graft. *b* The method of removal of the full thickness graft. (Abbott and Gill Medico-Surgical Tributes to Harold Brunn, courtesy of Univ. Calif. Press.)

Haas found that pain at the upper end of a spinal fusion can sometimes be relieved by resection of the impinging spinous process above the last fused vertebra

Influence of Fusion of the Spine on the Growth of the Vertebræ—Fusion of the spinous processes in animals causes definite changes in the growing vertebral bodies Although body growth goes on, Haas called attention to the inhibitory forces at work, evidenced by the tendency of the bodies to bulge anteriorly, the tendency to lordosis the tendency to compression of the intervertebral disk especially posteriorly and the tendency to premature ossification in the epiphyseal cartilaginous plates Advantage may be taken of distortion and inhibitions of growth caused by fusion of the spinous processes for the correction of existing deformities of the growing spine—in cases of tuberculosis, to correct kyphosis by the production of lordosis In cases of scoliosis, aside from the usual fixation after correction, it is possible that fusion can be produced outside the curve or in certain parts of an existing curve to exert a corrective influence, or to prevent increase of early scoliosis more satisfactorily than is possible at present

POST-OPERATIVE CARE OF THE BACK

The most important points to be observed in the post-operative care are (1) maintenance of water balance (2) maintenance of glucose balance (3) administration of vitamin C to promote wound healing (4) proper care of the wound including no meddling and infrequent inspection

Some patients are unable to take anything by mouth for several days after operation The consequence of such starvation is acidosis with the appearance of acetone in the urine

When dextrose is given in adequate amounts the glycogen storage is re-established and the acidosis disappears

Dextrose combats the acidosis and supplies calories One hundred grams of dextrose a day can easily be given Insulin is not necessary unless the patient is diabetic

After a major spine operation which prevents the oral intake of fluids for a few days a satisfactory water balance can be maintained with 3000 and not more than 4000 cc of fluids The intravenous drip method is best

The solution preferred is 10 per cent dextrose intravenously For the salt balance 1000 cc of Ringer's solution is used under the skin

The proper use of fluids and electrolyte solutions is responsible for saving many lives The general aim of parenteral fluid therapy is to maintain the body in an optimal state or if this be disturbed to restore it as quickly as possible with respect to blood and plasma volumes red cell mass and the water content electrolyte structure and acid-base equilibrium of the extracellular and intracellular compartments

Bodansky lists the following substances as helpful in parenteral fluid therapy

1 Whole blood and plasma

2 Water in various solutions

3 Electrolytes particularly the chloride sodium potassium bicarbonate and lactate ions

layers of cortical bone without a central portion of cancellous bone The posterior third of the crest is the thickest part of the bone This thickness is increased down to the level of the sacro iliac joint

Abbott and Gill are strong advocates of cancellous bone as the most suitable material for bone grafting It has evident advantages in many conditions for which bone grafts are necessary The method of removal of iliac grafts is both simple and atraumatic The varied contour of the iliac crest allows the removal of grafts of the types needed for varying conditions The more rapid reorganization of iliac bone in comparison with cortical bone from the tibia can be ascribed to its cancellous texture

Abbott and Gill find that cancellous bone is more rapidly revascularized and revitalized by living bone than is the cortical bone It is plastic and can be molded to surfaces of various contours and in addition it possesses a certain rigidity when full thickness grafts are employed Tibial grafts revascularize slowly Their principal value lies in their rigidity Chandler finds that radical treatment of the lateral articulations is essential The placement of large iliac grafts permits fixation with optimum relations of the 4th and 5th lumbars with the sacrum The fixation of the grafted area with 035 18-8 wire immobilizes the graft and host tissues favoring more complete vascularization and union No external support is needed and the patient is permitted to get up and about as soon as he desires

BONE REGENERATION AND TRANSFORMATION IN OSTEOSYNTHESIS OF VERTEBRÆ

In 1934 Orell demonstrated that transplantation of small pieces of bone subperiosteally on the anterior medial wall of the tibia produced new bone the fastest and more abundantly in the spaces between the piece of bone and the tibia and especially in the spaces between the periosteum bone and the tibia The bone gradually becomes rich in collagen and calcium content so that after a period of five to six weeks it is impossible to remove the bone from the tibia without the aid of a chisel The implantation of os purum fresh or boiled bone produces the same result

On the basis of these facts newly formed soft bone has been produced for clinical transplantation by implanting os purum subperiosteally on the tibia and after six to seven weeks dependent on the patient s age removing the thus formed os novum

This same os novum has been employed in osteosynthesis of vertebræ The method then used was described by Orell in 1942 An account is also given of 33 cases of osteosynthesis which were treated according to this operative method in cases of spondylitis Since that time a further large number of patients have been operated in this manner at present about 200 cases inclusive of cases of spondylitis and disk degeneration

The os novum is divided into long narrow strips which are subsequently placed between the spinous processes arches and articular processes By reason of its flexibility the graft can easily be moulded to the underlying surface by pressure with a spatula

It is important that the vertebral bone surfaces are completely exposed and well decorticated

NOTES

For those persons who have a storm a few days following adequate surgical procedure I have found a very effective regimen

1 Tolserol intravenously every other day

2 Butazolidin—1 tablet t i d

The disturbances of function following operations on the back are limitation of motion and loss of strength Both of these may be caused by atrophy of the muscles

Many failures of spinal fusion operations are due to faulty technic rather than to the method employed

Note There is a 10 per cent chance of fracture of a leg after taking a *tibial graft*

HEALING OF WOUNDS

Healing of wounds depends on mechanical, chemical and circulatory conditions the vitality of tissues, the circulation the condition of the soft tissue liver, and the approximation of like tissues

Vitamin C aids wound healing

Wounds *will* not *heal* unless the blood protein equals 6 5 *mgm per cent*

One specific factor that delays wound healing is cortisone

The Factors that Encourage Wound Healing Are

Good surgery
Proper dressings
Appropriate diet including adequate proteins
Normal blood chemistry
Vitamin C
Other vitamins and minerals
Testosterone

Aids in the Performance of Good Surgery

(1) non traumatic handling of the tissues
(2) avoidance of excessive or rough sponging
(3) the use of suction
(4) electrocoagulation of bleeders,
(5) keeping all unnecessary instruments out of the wound

Just Before Operation —One should make a short cross incision through the skin at the level of the interspace to be explored first after its identification If a long incision or a curved one is to be made several superficial scratch cuts can be made to be matched up when the incision is finally sutured

4 Ammonium chloride
5 Protein or products of protein digestion, carbohydrate and fat
6 Vitamins

WATER BALANCE DURING OPERATIONS ON THE SPINE

Patients with lesions of the spine requiring surgical treatment may have chemical abnormalities requiring the replacement of blood, water, sugar and salt

An adult patient convalescing smoothly from a major spine operation vaporizes from 1000 to 1500 cc of water daily When fever or other disturbances increase heat production this figure averages 1500 to 2500 cc daily Aside from this water loss through vaporization, the average adult patient needs about 1000 cc of water daily to enable the kidneys to carry out their function without having to work at maximum capacity

The daily water requirements of surgical patients range from 2000 to 3500 cc daily When vomiting is present these figures are proportionately raised Saline solution has proved valuable in replacing the sodium chloride supply depleted through water loss and vomiting

A patient who cannot take enough fluids by mouth after operation must receive sufficient replacement by other means The intravenous drip method or venoclysis is the answer to this problem Glucose is usually added to the solution to supply a source of nourishment A 5 per cent solution of glucose in saline is the most popular substance used This can be changed to or alternated with a 10 per cent solution of glucose in sterile water when peripheral edema indicates an excess of sodium chloride

Other sources of nourishment the proteins and fats are not supplied by this method When they are needed blood transfusion or the newer types of protein infusion can be used

Darrow and Pratt believe that the proper use of water and electrolyte solutions is responsible for saving more lives of seriously ill patients than is the use of any other group of substances

Fluids for Parenteral Feeding —Parenteral feeding is limited to vitamins and solutions of dextrose and amino acids since intravenous injection of fats is still in the experimental stage Amino acids and protein hydrolysates may supply the protein needs when combined with dextrose About 2 Gm per 100 calories metabolized is the usual amount given in twenty-four hours that is about 1 Gm per kilogram in adults and 2 5 Gm per kilogram in infants The amino acids are usually combined with dextrose water and electrolyte so as to meet all the expenditure of water and electrolyte A mixture of 2 Gm of amino acids in 150 ml of 10 per cent dextrose yields about 68 calories while 2 Gm in 225 ml of 10 per cent dextrose yields 100 calories These units are appropriate amounts to be given per estimated 100 calories metabolized

An intravenous infusion of dextrose in normal saline should be started as soon as the incision is made Compatible blood should be at hand for immediate instillation if circumstances demand

Use autogenous iliac bone instead of tibial bone throughout the procedure

LUMBOSACRAL FLEXION ARTHRODESIS

Swisher performs arthrodesis of the lumbosacral spine in flexion, in the average chronic case with low back pain which may be due to displacement or arthritis of the facets, narrowed intervertebral foramina, relaxed lumbosacral joints disk degeneration and protrusion, and backward displacement of the fifth lumbar vertebra

The principles of successful bone grafting include suitable grafting material (iliac bone), compression, and immobilization The use of screws through the facets reinforces the immobilization obtained by a mortised bone block

To shorten the convalescence and to provide reliable stabilization of the spine so that early return to manual work is permitted Roger Anderson evolved a method based on the following three principles

1 Complete excision of the pain-bearing articulations,

2 Use of donor grafts in the form of bone crumbs,

3 Lateral placement of the grafts

Complete excision of the capsule, cartilage and subarticular bone not only removes the pain-bearing structures but exposes the cancellous, bleeding bone forming a V- or U-shaped trough

The bone crumbs obtained by cutting up spinous processes chips of laminae subarticular bone and bone from the crest of the ilium or from the bone bank supply an excellent grade of cancellous grafts When closely examined the crumbs will be seen to have fine burdock bur-like projections

Lateral placement of the bone burs gives a most favorable situation for stabilizing leverage because the grafts are directly in the axis of the resected joints A continuous cancellous base is supplied

Technic —Through one midline incision a generous amount of bone is removed from the crest of the ilium and the involved spinous processes and at least two processes above are cleansed and resected

Laminae and dorsal portion of the pedicles are meticulously cleansed to the outermost lateral edges and the capsule resected

The joints are resected and all presenting bone ploughed (chiseled) down to bleeding bone Bone crumbs are pressed into two bilateral mounds

Although only a surprisingly few instruments are required, they must be of the best quality The one mechanical retractor must be dependably effective, the two curettes and bone cutter must be keenly sharp, nothing less than the equivalent of a Stille, and the two chisels must be curved and finely edged

After removing every vestige of soft tissues from the lamina pedicles and articulations the joint can be excised in the manner illustrated or taken out piecemeal

The lateral cartilage is resected after which the dense subarticular bone is removed

The crumbs are placed in the lateral troughs and pressed together As the blood coagulates, the mass forms a matrix If sufficient bone burs are present they may extend over the midline

It is very important to obtain good exposure of the various back structures. Among the *difficult elements are the intervertebral articular facets* (zygapophyseal joints).

There have been devised, therefore, several types of retractors. Among the most useful is the Hibbs model. Taylor designed a useful simple retractor which is shown in Figure 88. It is of definite aid in simplifying and facilitating a strenuous surgical procedure.

After the musculature is stripped from the spines and laminae, the lateral facet at the level needing retraction is palpated. The tip of the retractor is then caught on the lateral surface of this facet, which becomes the fulcrum upon which leverage is made for the retraction of the muscles and the cutaneous tissue.

A word of caution must be given, because the leverage exerts a powerful force. If this is maintained too strenuously and for too long a time, the soft tissues may sustain unnecessary pressure necrosis.

Moore and Cook and Nicoll designed the prop graft operation for the surgical fusion of an unstable spine.

Moore uses a double notched graft which is placed between the spinous processes with the spine in flexion and which locks when the spine is placed in extension. Although the bone for this graft can be removed from either the tibia or the ilium, an iliac graft is superior.

Bosworth began using the "clothespin" graft for use in treating laminal defects and cases of spondylolisthesis in 1942. He referred to a similar graft reported by Gibson. The basic principles of both of their grafts are similar to the one described independently by Moore and Nicoll.

The operation is done under low spinal block anesthesia and is accomplished in two stages. The first phase is performed with the patient lying supine on the table with pillows under the pelvis. The coagulating current and a special suction tip should be readily available during the operation.

Bosworth's Technic of Spinal Fusion in the Lumbosacral Region by the Double Clothespin Graft (Distraction Graft or H-Graft).—Bosworth warned that this is an extensive procedure not to be undertaken lightly (Fig. 74).

The operation is carried out with the patient ventrally recumbent on a table which will flex at a point beneath the pelvis. Most of the operative work is carried out with the foot of the table lowered so that the extremities are dependent in order to open up the interspinal spaces posteriorly. To separate the spinous processes still further, the head of the table is lowered at the time of implantation of the cortical portion of the graft. Considerable flexion of the patient is essential at the time of placing the graft so that firm stability and fixation thereof may be maintained postoperatively should the patient inadvertently reassume a position of semiflexion.

The basic conditions for which the operations were performed were spondylolisthesis, typical herniated low-lumbar disk, laceration of disk with no posterior protrusion, lumbo-sacral strain, fractured lamina and facets, cicatrix of previous exploration, arthritis of facets, and osteochondrosis.

One should use a routine technique with as meticulous a preparation for the placing of grafts as possible when doing lumbosacral fusions.

Arthrodese only L5 or L4 to the sacrum if possible, waiting until a later date to add other segments above unless the situation at the time of the first operation absolutely demands fixation of a greater number of segments.

omitting a fracture board from the bed so that the mattress presses against the fragments For the first few weeks, whenever the patient is in bed he is kept flat on his back

The patient can get out of bed without bending his back After being rolled over on his abdomen, he pushes himself out of bed with his arms without any harmful movement of the spine The same maneuver, in reverse is used in getting back into bed with all bending taking place at the hips

Patients are instructed to stand walk and sit with the spine straight or in some lordosis whichever is normal for them Since no brace or cast is used the normal apprehension of the patient causes him to make an extra effort to walk erect

The two outstanding advantages of the arthrodesing method are first the high percentage of successful end results, and second, the short im-

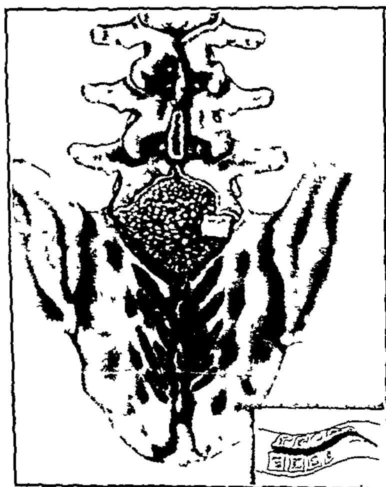


Fig 90 —The nucleus pulposus has been removed together with as much nuclear material as possible from between the bodies of the vertebrae A spinous-process peg might have been driven in between the bodies of the vertebrae to stabilize them The exposed nerve root has been covered by a piece of free fat The spine has been placed in a normal prone position as shown in the drawing The bone chips have been laid in place On the right side a squared off piece of spinous process has been plugged in between the fifth lumbar articular process and the sacrum and then partially covered by chips This is an optional variation in the technic also used to give temporary stability Note that the bone chips are small (Briggs and Milligan courtesy of J Bone & Joint Surg)

A single layer of absorbable gauze is now routinely used to keep the crumbs from shifting. Sufficient soft tissue and muscle are left to cover the articulation and the lamina above so as to avoid any undesirable encroachment. The two spinous processes above and a good deal more bone is removed than is shown.

As the retractors are removed the lumbar muscles are lifted up and carefully placed over the mounds of bone forming a continuing cover, followed by routine closure. The mounds of bone are placed laterally in the axis of the articulations.

Following the operation pain reflexes cause contraction of the lumbar muscles which splints the spine. Further immobilization is obtained by

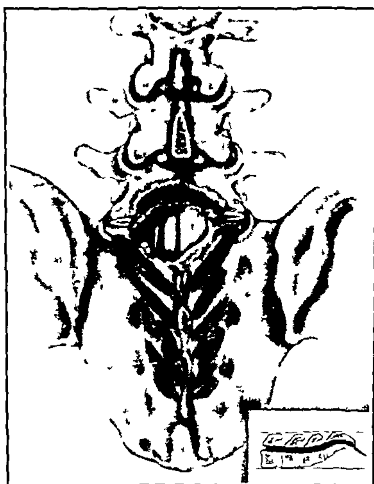


Fig 89.—This drawing shows the essential features of the operative technic. The spine has been placed in flexion. The sacral and fifth lumbar spinous processes have been removed together with the inferior overhanging portion of the fourth lumbar spinous process. The laminae of the fifth lumbar vertebra have been squared off and the posterior cortex turned back to form a buttress for the bone chip. The inferior portion of both articular processes of the fifth lumbar vertebra have been removed exposing both facets. The ligamentum flavum has been removed on the left side and split on the right side. The interlaminal space has been enlarged by removal of a portion of the sacral lamina and articular processes on the left side together with some of the fifth lumbar lamina thus exposing the dura, the first sacral nerve root and a herniated nucleus pulposus. The fusion bed has been prepared. Note that the gouge grooves on the sacrum are carried down onto the sacral articular processes. The cartilage of both facets has been removed. (Briggs & Milligan, courtesy of J Bone & Joint Surg.)

CHAPTER 17

CONGENITAL DEFECTS OF THE SPINE

THE recognition and evaluation of the importance of congenital anomalies of the spine is imperative, especially in cases of compensable trauma and military and medico-legal situations

Steindler believes that backs endowed with anatomical variations are inherently weak by virtue of natural restrictions of normal motion, and their possessors are especially susceptible to ligamentous sprains in the sacro-iliac and sacrolumbar regions

The chief congenital variations are (1) reduction in number of parts, (2) increase in number (3) fusion of parts, (4) rachischisis, (5) variations in shape such as wedge-shaped vertebræ, (6) abnormalities of the ribs

Vertebral anomalies are of three main types (*a*) morphological variations, (*b*) numerical variations, (*c*) errors in regional differentiation (suppression) Morphological variations are manifested by wedge-shaped vertebræ, by independent body halves or by other signs of developmental arrest in the bodies of the vertebræ In the posterior portions of the vertebræ, they are represented by failure of the separate centers of an arch to fuse, leading to pseudo-articulations between arches and pedicles This variation in the lumbar region predisposes to spondylolisthesis

Numerical variations consist essentially of assimilation of vertebræ, either to the cranial or caudal end of a section of the spine

In occipitalization the first cervical segment assumes the characteristics of the occiput It is common to find the vertebræ of one section numerically increased at the expense of those of another section

Lumbosacral numerical variations consist of sacralization of the 5th lumbar vertebra and lumbarization of the 1st sacral segment In general, numerical variations occur in from 15 to 22 per cent of human spines Females are more liable to variations in the cranial direction, whereas males incline more toward caudal variations

Spina bifida occurs when there is a failure in fusion of the ossification centers of the pedicles and arches

A summary of 1000 symptomless spines examined by Bohart showed anatomical variations spina bifida occulta processes being the most common Variations in the lumbosacral region predispose to backache The presence of abnormalities frequently leads to legal complications after an injury To prevent this and to protect the workman with a potentially weak back from serious back strain, all workers whose occupation might result in back injuries should be given the benefit of roentgen study of the spine before being employed

The medico-legal aspects are important because of controversies inevitable in court, one group of "experts" claiming that these anomalies and variations are insignificant another group asserting they are all-important

bulatory convalescence Patients are usually out of bed in one week without brace, cast, or other support, and the majority of patients leave the hospital in two weeks time The more bone, the better the chance of success

The removal of a sacralized transverse process in a large adult is one of the most formidable procedures in low back surgery Putti's successors (Delitala, Pais, *et al*) have discontinued the removal of a sacralized fifth lumbar process They believe the trouble is always a disk derangement Just when Putti taught us how to resect a sacralized process, we find it is not necessary or even desirable

Descriptions of Mercer's, Burns and Merle D Aubigne's operations are in the section on Spondylolisthesis

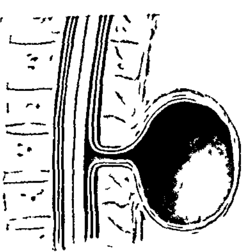
Tri-sacral fusion involves a tremendous amount of surgery to keep a disk in its little cubby hole

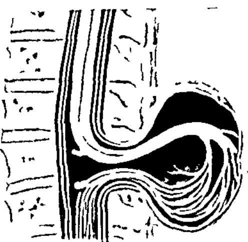
Osteotomy is performed to correct deformity, especially in Spondylitis Deformans

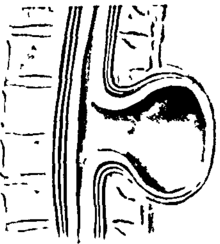
WISE WORDS IN RELATION TO SURGICAL TECHNIC

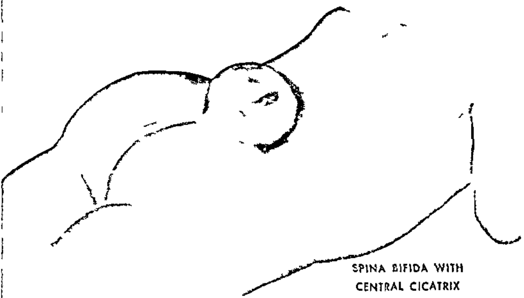
Easy does it
Take your time
Use 2 pairs of gloves until skin is isolated, then remove 1 pair
If you change gloves re-scrub Use an antiseptic spray and powder
It is safer to add a new glove over the torn or contaminated glove
Do not crush any more tissue than absolutely necessary
Use mosquito snaps wherever possible
A periosteum elevator should not be used as a scraper
Beware of pressure by ribbon retractors
Never allow retractor prongs to dig into vessels, nerves or muscles
Do not pull hard on retractors
Too vigorous retraction causes nerve and blood vessel damage
Stretching of tissues does more harm than cutting them
A subperiosteal approach minimizes hemorrhage
Do not cut anything you can not see
Beware of silk in the presence of infection
Complete hemostasis is imperative
Diathermize blood vessels before cutting them
Avoid dead spaces they predispose to and harbor infection
Interrupted sutures are preferred
Loose suturing is desirable
Nurse must watch the operating team's backs for contamination

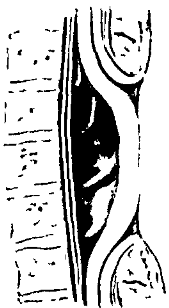
PLATE II











Spina Bifida (From *Ciba Collection of Medical Illustrations* Vol I—*The Nervous System*)

The middle ground is undoubtedly correct, *viz* that these variations render the spine more vulnerable to stress and strain Medico legal necessities tend to exaggerate pre-existing conditions especially in the cervical spine and in the lumbosacral area A person may have congenital anomalies of a rather high degree and never know it until a film is made for some special reason or when an injury or illness occurs and the spine is studied by the roentgen-ray

Spina Bifida —Spina bifida is a congenital defect due to incomplete closure of the vertebral spinous process and lamina Failure of closure of the neural arches is dependent on a disturbance of early embryonic development True spina bifida presents external evidence, but spina bifida occulta may be unsuspected The defect is said to occur once in 800 births

Spina bifida occulta is a congenital malformation of the spine, consisting of a faulty development of portions of the spine, usually the laminæ The malformation may present itself as a cleft or incomplete fusion of the lamina, it may appear as a defect of the bone between adjacent laminæ it shows considerable variation in size and shape occurring on one or both sides of the midline It may be single or multiple It is most commonly situated in the upper three sacral laminæ It is relatively rare in the 5th lumbar vertebra

Dittrich emphasized the importance of spina bifida occulta and its association with pathological alterations within the spinal canal, which consist of masses of fibro-adipose tissue overlying the dural sac and the nerve roots in the sacral canal In addition cords of fibrous tissue are found extending between the ventral surface of the laminæ and the dura or the nerve roots

Spina bifida occulta is found most commonly in the lumbosacral region and is frequently associated with other abnormalities

In the human fetus the entire neural tube closes near the end of the *third week of intra-uterine life The vertebral arches from the 1st cervical* to the 3d or 4th sacral are normally closed by the eleventh week Until the third month the spinal cord and vertebral column are of equal length After this time with the growth of the fetus, the vertebral canal becomes proportionally longer, a process which eventually leaves the conus medullaris at the level of the 1st lumbar vertebra in a normal man If the spinal nerve roots or spinal cord are involved in a developmental defect, the upward migration of the cord is embarrassed and may produce late symptoms

Complete rachischisis or splitting of the vertebral column with exposure of an undeveloped spinal cord represents an extreme developmental anomaly

Spina bifida may be classified as follows (1) spina bifida with meningocele, (2) spina bifida with myelomeningocele, (3) rachischisis, (4) spina bifida occulta posterior (or anterior) with meningocele, (5) spina bifida occulta posterior (or anterior) with myelomeningocele

Motor and Sensory Disturbances —The motor disturbances include progressive paralytic foot deformities The cavus or clawfoot deformity is the most frequent of the late symptoms of spina bifida occulta Flaccid paralysis may occur late in life and denotes a more serious lesion of the spinal cord

Sensory symptoms include hyperesthesia, anesthesia, hemi-anesthesia, and trophic and vasomotor disturbances Perforating ulcers may lead to deep necrosis and even to osteomyelitis of the underlying bone Incontinence of the bladder is not infrequent Contractures of the spastic or clonic type may occur in the lower extremities

Roentgen ray Findings —There is usually a median cleft of the 5th lumbar vertebra as well as of the 1st sacral neural arch and sometimes other adjacent segments There may be an abnormal enlargement of the sacral hiatus, even though the laminae meet in the midline

Asymmetry of the 5th lumbar vertebra or suppression of one-half of this body is often found This may lead to deflection of the lumbar curve



Fig 91 —Hemivertebra between 3d and 4th lumbar vertebræ Note the scoliosis

and scoliosis It is common to find other bony anomalies associated with spina bifida occulta thus clefts of the bodies of thoracic vertebræ lumbarization of the 12th thoracic vertebra, synostosis of various vertebræ and rachischisis

Surgical treatment of spina bifida occulta is indicated when progressive symptoms are present, when trophic and circulatory symptoms are severe and when there is incontinence of the bladder or rectum Occasionally surgical correction is indicated in the presence of spastic symptoms, ulcers and advanced clubfoot

The operation consists of resection of the ununited portions of the spinous processes or laminæ with bone bridging for solidification When a fatty tumor is present, it should be resected The only contraindication to operation is the presence of a defect so large that it can not possibly be covered The best results have been obtained when the deformity is repaired shortly after birth

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Congenital Scoliosis Due to Accessory Vertebræ —Congenital scoliosis may be due to single or multiple wedge-shaped accessory vertebræ Royle approached such vertebra through a vertical incision made over the lateral border of the lumbar or thoracic fascia

The posterior compartment of this fascia was opened and the posterior layer was retracted medially together with the sacro-spinalis muscle The tips of the transverse processes were sought beneath the muscle There may be considerable rotation It may have a cartilaginous rib attached It is usually wedged between two vertebra Careful dissection is necessary The spinal ligaments may not be attached to it The adjacent surfaces of the vertebræ may show cartilaginous articular facets against which the accessory hemivertebra rests

Removal of the body and posterior arch of a hemivertebra in the lumbar region is the only means of correcting a lateral curvature caused by this anomaly, according to von Lackum and Smith This procedure should be supplemented by a spine fusion operation Other writers who reported cases of hemivertebræ were Codivilla, Compere and Mayer

SAGITTAL CLEFT (BUTTERFLY) VERTEBRA

Rokitansky described a congenital division of the twelfth thoracic vertebral body into two lateral halves with an intervening sagittal cleft The typical butterfly appearance described by Fischer and Vandemark is seen on the anteroposterior view where the wings of the butterfly are represented by the two symmetrical halves of the vertebral body The two halves may be separated by a wide cleft bridged by strands of bone a bony bridge or demarcated only by a narrow sagittal cleft between the two halves Other vertebral and rib anomalies may be associated

CHAPTER 18

BODY POSTURE—BODY MECHANICS

According to Baker it was development of a true foot that gave man his opportunity to develop his remarkable superiority over other primates, who really possess four hands. With the development of his upright posture came the increase in the size of the brain and the great increase in intellectual powers. Goldthwait was one of the first clinicians to recognize the relation between the erect posture and health and to insist on the correction of body mechanics as an important part of the treatment of chronic diseases.

The tilt of the pelvis, which is controlled partly by the abdominal muscles but largely by the muscles which control the position of the pelvis with relation to the femurs, causes variation in the compensatory curves of the spine and postural strains result, followed by traumatic arthritis, particularly when there is sharp angulation at the lumbosacral junction.

The cervical portion of the spine developed its curve, with the resulting balance of the head on the spine, very late with respect to other changes.

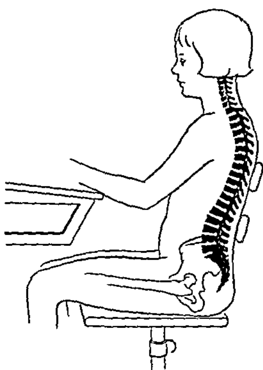
The midcervical portion of the spine where the anterior curve is marked is the point of the most constant strain. Arthritis and narrowing of intervertebral spaces are common between the 5th and 6th cervical vertebrae and to a less extent between the 4th and 5th. Strain or changes in the angulation in any of the spinal curves which tend to cause decrease in the size of the foramina result in irritation of sensory nerves and cause radiating pain. Radiation around the trunk frequently causes pain which simulates visceral disease.

Body mechanics means the mechanical correlation of the various systems of the body with especial reference to the skeletal muscles and their association with the nervous system. Postural disturbances lay the mechanical foundation for future strains, injuries and infections.

The person with an erect carriage thinks better, his muscles, bones, joints, ligaments, abdominal organs, blood vessels, eyes and brain function better. During twenty-four hours of the day we stand, sit, lie, walk or run. We spend about one-third of the time in sleep.

A study of posture should be part of every medical examination. In interpreting results the pediatrician, the orthopedist and the physical therapist, all have valuable contributions to offer. Requirements for correct standing posture prescribe that an imaginary plumb line dropped from the side of the head should pass through the middle of the ear, shoulder, hip, knee and lateral malleolus.

The pioneer advocate of good posture in America was Goldthwait, who said: "To have the various parts of the body so perfectly adjusted that easy balance and graceful use must result, is to be desired for reasons of far greater importance than the esthetic. Such elements are of absolute



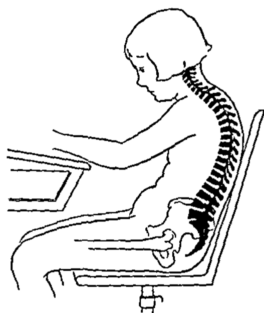


Fig 92 Fig 93

Fig 92 —Excellent sitting posture (Bennett s Essentials in Hygienic Seating courtesy of American Seating Company)

Fig 93 —Illustrating skeletal deformity in poor sitting posture Note the rounding of the *thoracic spine and the flattening of the lumbar spine* (*Bennett s Essentials in Hygienic* Seating courtesy of American Seating Company)

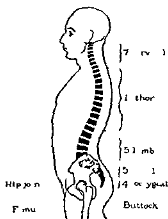


Fig 94

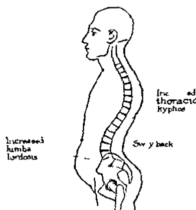


Fig 95

Fig 94 —Lateral view of normal head torso and pelvis posture showing sections of vertebræ (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

Fig 95 – *Increased lumbar lordosis sway back resulting in increased thoracic kyphosis* Diagrammatic and exaggerated (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

importance for perfect health and the fullest economic efficiency, since use of the body in proper poise insures the least friction, with consequently, the greatest amount of energy available for whatever may be required of the individual" Bad posture induces fatigue, which in turn predisposes to further bad posture Many disorders of the body are due as a whole or in part to poor posture Muscular weakness can be inherited Unequal muscle pull or muscle imbalance produces posture disturbances

There are many variations in the structure of the bones of the spine and in the attachments of ligaments and muscles which maintain and control the integrity of the spinal column as a whole Any abnormal relation of the muscular and fascial structures of the extremities to the spine affects the mechanics of the spine

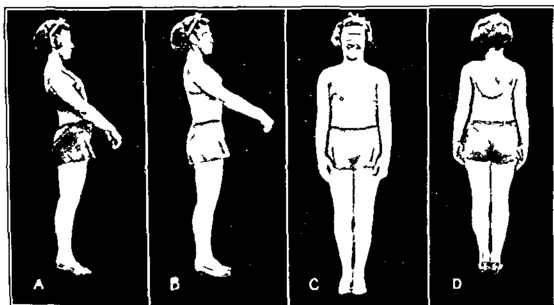


Fig 96 —*A* Poor posture due to throwing the shoulders back and nothing else This produces sway back and pot belly *B* *C* and *D* Excellent standing posture from the side front and back The arms are extended forward to expose lumbar region to view (Lewin in Principles and Practice of Physical Therapy courtesy of W F Prior Company Inc)

Postural Anatomy —The spine is a flexible rod made of segments Its normal physiological curves are the cervical forward curve, the thoracic backward curve, the lumbar forward curve and the sacral and coccygeal backward curves The fetal spine presents only a thoracic and a sacral curve, but as the child assumes erect posture, two secondary curves develop—the cervical and the lumbar Until puberty these primary and secondary curves pass almost imperceptibly into one another

Any lateral deviation involving more than one vertebra is called scoliosis A child may inherit a certain type of back and a certain type of posture

CAUSES OF POOR POSTURE

The problem of posture involves every occupation and profession as well as individual habits and personal accidents Such static deformities as flat-feet, sway-back and inequality of length of legs, not only contribute

to poor posture but may indeed cause a chronic painful back. Systemic infections contribute to poor posture. Poor bed posture may well contribute to poor standing posture. Regardless of how nearly perfect the lighting may be, faulty sitting posture in reading, studying, painting or playing the piano may injure the eyes. Likewise, children who read for hours humped over a desk can injure their eyes.

Undernourished persons present the typical stooped figure of poor posture. A protruding abdomen or pendulous breasts contribute to poor posture. Many girls during puberty and in subsequent years develop habitual poor posture in a self conscious attempt to hide their developing breasts. Boys at this age may develop a slouch. Rapid growth is another cause of poor posture. Persons of all ages who have a feeling of self-consciousness tend to become round-shouldered and sit or stand with awkwardly poor posture. Those who sit for long hours working at a bench or desk, bicyclists, musicians and wrestlers are prone to poor posture.

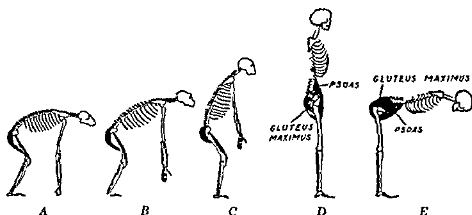


FIG 97 —Functional disturbances attributable to the development of the erect posture. *A*, *B* and *C*, Muscular shifts in the extension and straightening of the knees and thighs. *D* and *E*, development of antero-posterior curves in the erect position. (Baker, courtesy of Arch Phys Therapy.)

Other causes of poor posture are congenital malformations, ear lesions, eye defects, fatigue, injuries of extremities from wearing a cast on an arm or leg for a long period, intervertebral disk lesions, intraspinal tumors, misfit clothing, misfit shoes, misfit seats, nerve injuries, removal of one breast, respiratory lesions, sciatic neuritis and spondylolisthesis.

Chicken breast (pectus carinatum), a postural deformity seen in children, is usually due to rickets or to a cardio respiratory disturbance.

Funnel chest (pectus excavatum) presents a depression of the middle and lower portions of the sternum. The causes in children are usually nutritional, especially rickets.

Physiologists say that one-fourth of the total quantity of blood is in the peripheral circulation, one-fourth in the heart and lungs, one-fourth in the liver, and one-fourth in the remaining abdominal viscera. The crowding which results from poor posture embarrasses the heart, lungs, diaphragm, stomach, liver, gallbladder, pancreas, small intestine, large intestine and omentum. One result is intestinal stasis which in turn predisposes to other chronic conditions.

Human beings were not intended to walk upright Many of their disorders are penalties for his having assumed the upright position, as a result of which their organs may be in a state of chronic congestion The uterus, ovaries and fallopian tubes suffer especially The superimposition of menstrual congestion on an already congested pelvic organ results in dysmenorrhea and menorrhagia

An exaggerated lumbar lordosis throws strain on the lumbar and pelvic ligaments and muscles Poor posture of the lower extremities causes strain on the hip, ankle and foot, which predisposes to arthritis Strain, overactivity, trauma or infection superimposed on flat-foot, results in disability

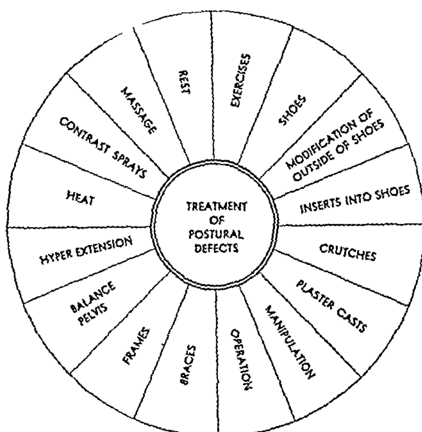


Fig 98

Orthostatic albuminuria is a syndrome characterized by albumin in the urine, found after the person has been standing for long periods

The effect of posture on the central nervous system involves the normal physiology of the brain, the spinal cord and the nerves which control the movements of the limbs Our brains would not be worth much if we did not have muscles to perform the acts prescribed by them

The various postures assumed by a child during the twenty-four hours include posture in bed while sitting, during play and in running Preventive measures should be adopted at key points in the child s activity The sitting posture is important while at school, at the dining table, in study at home and at rest One of the most important advances in the fight against incorrect posture is the provision of proper school seats

The child must have a proper seat and should be taught how to adjust it to obtain maximum efficiency. Makers of proper seats for school children and stenographers deserve much credit for their research, engineering and construction. A child should sit erect at the dining table.

Disturbances in eyesight produce postural defects, and these in turn predispose to eye lesions. Eye strain produces mental and physical fatigue. One must use his eyes correctly or he cannot relax.

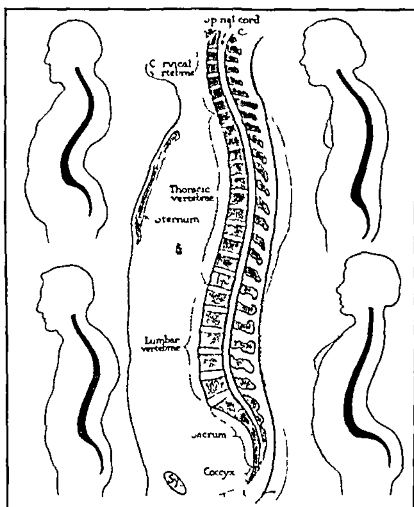


FIG 99.—Normal spine, lateral view. Central figure shows lateral view of a median sagittal section of the torso. The 4 figures on the sides illustrate different types of antero posterior deformities. (Courtesy S. H. Camp Co.)

Posture Prophylaxis.—The most important prophylactic measure is the establishment of good posture as an automatic, involuntary or unconscious effort. The person with bad posture is taught to "stand tall, sit tall, lie tall and think tall."

Methods of Recording Posture.—Posture is recorded by means of the camera, the schematograph and the silhouettograph. Harris poses the subject behind a wood frame which is divided into sections by pieces of string secured at intervals of 2 inches from top to bottom and from side

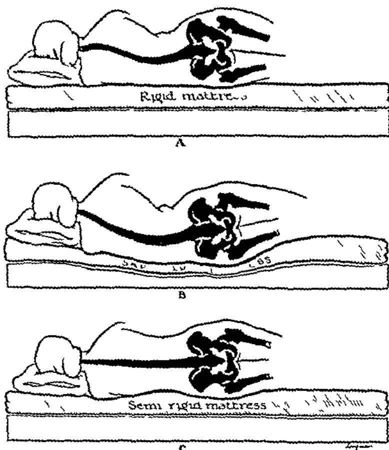


Fig. 100.—*A*. Rigid mattress causes curvature of the spine when the patient lies on her side due to elevation of pelvic and shoulder girdles. *B*. Sagging mattress causes curvature of spine due to improper support of the heaviest portion of the body. *C*. Semi rigid mattress supports all parts of the body properly.

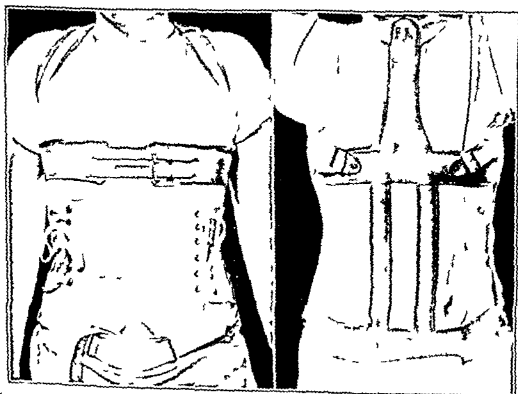


Fig. 101. Kleinberg type of spine brace. Valuable in posture cases. (Lewin's Orthopedic Surgery for Nurses, courtesy of W. B. Saunders Company.)

to side Roentgenograms determine the position and the shape of the bones and reveal old epiphyseal or joint disturbances

Body Types — Thompson called the limbs the servants of the trunk, transporting it from place to place, bringing it food and drink and performing other duties in its behalf Stockard classified body build as linear, intermediate and lateral Davenport pointed out that body build is a relation of volume to stature He found that body build and nutritional status bear a reciprocal relation

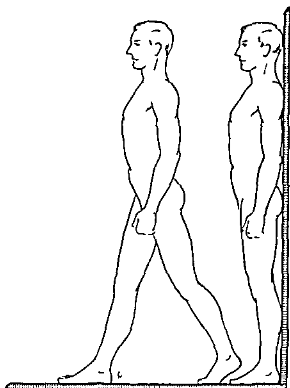


Fig 102 — Excellent standing posture

TREATMENT OF POSTURAL DEFECTS

In the treatment of postural defects the sleeping mattress must be semi-rigid The Bradford, Whitman or Herzmark frames are indicated when the postural defect is severe

Medical gymnastics comprise postural and corrective exercises the latter including flexibility, power, breathing and relaxation exercises A person who performs the following movements will find himself in excellent walking posture (1) Stand with back against the wall (2) Flatten the lumbar region, attempting to touch the wall with the lumbar spine (3) Then, holding the body erect shift the weight forward to the balls of the feet, and step off, maintaining the body in this position The subject should keep his head up so that he looks out of the centers of his eyes

The patient's interest should be aroused by showing him photographs or shadowgraphs of himself in poor and in proper posture Breathing exercises are important Swimming and diving, skipping the rope and tap dancing

are valuable The "grunting" exercise is helpful in "pulling in" the abdomen

When support is necessary a simple corset is to be considered first, then a corset reinforced either with a steel frame or with an aluminum cage The spine braces described by Taylor, Goldthwait, Osgood and Swaim or Kleinberg may be used Celluloid jackets and removable plaster-of-Paris casts are of value Supports for visceroptosis may be required Massage is beneficial Hydrotherapy and heliotherapy are helpful

(The United States Department of Labor, Children's Bureau, Publications Nos 164 and 165, prepared by Dr Armin Klein, should be read by



Fig 103 —Good standing posture

every one interested in posture work) The exercises prescribed for postural defects are well known and can be found in monographs on the subject

POSTURAL BACK PAIN OF PREGNANCY

The exaggerated lordotic curve of pregnancy may irritate spinal nerve roots and produce pain in the lower back and abdomen

Bushnell finds that pain and tenderness usually occur in the sixth and seventh months over part or all of the regions supplied by the ilioinguinal and ilio-hypogastric nerves Tilting of the pelvis to one side or shortening of one leg may cause unilateral discomfort

to side. Roentgenograms determine the position and the shape of the bones and reveal old epiphyseal or joint disturbances.

Body Types.—Thompson called the limbs the servants of the trunk, transporting it from place to place, bringing it food and drink and performing other duties in its behalf. Stockard classified body build as linear, intermediate and lateral. Davenport pointed out that body build is a relation of volume to stature. He found that body build and nutritional status bear a reciprocal relation.

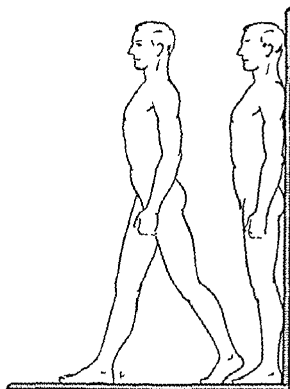


Fig. 102.—Excellent standing posture.

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The patient's interest should be aroused by showing him photographs or shadowgraphs of himself in poor and in proper posture. Breathing exercises are important. Swimming and diving, skipping the rope and tap dancing

Superficial tenderness is shown by pin prick or stroke or by compressing a fold of skin and fat between the fingers. To elicit deep tenderness, the skin is firmly pressed against muscle or bone. The patient is instructed to lie on her back, knees raised and heels supported at coffee table height, for twenty-minutes four times a day.

Procaine infiltration of nerve roots gives temporary relief. Persistent unilateral pain may require a heel lift to level the pelvis.

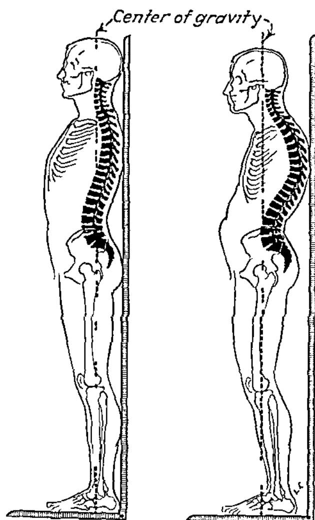


Fig. 105.—Normal standing posture (left). Poor posture (right).

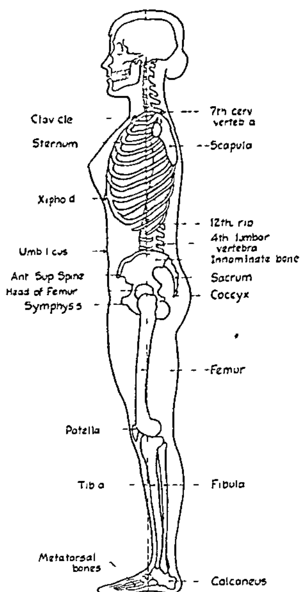


Fig. 104. Relation of bones in good standing position



Fig 108 —Very poor sitting posture (Courtesy Cosco Chair Co)

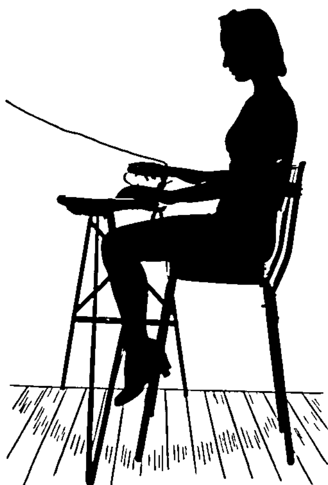


Fig 109 —Good sitting posture of a housewife while ironing (Courtesy Cosco Chair Co)



Fig 106 —Good sitting posture (Courtesy Co co Chair Co)



Fig 107 —Poor sitting posture (Courtesy Co co Chair Co)

CHAPTER 19

DISTURBANCES OF VERTEBRAL EPIPHYSES

ADOLESCENT KYPHOSIS

(Scheuermann's Kyphosis Dorsalis Juvenilis)

Under the term, kyphosis dorsalis juvenilis, Scheuermann, of Copenhagen in 1921 called attention to the clinical significance of the epiphyses located at the superior and inferior borders of the bodies of the vertebræ He named the lesion affecting them "osteochondritis deformans juvenilis dorsi," which is now referred to as "Scheuermann's disease" and is analogous to the Legg-Calvé-Perthes and Osgood-Schlatter syndromes

Snoke, described the "apprentice's kyphosis" as a round thoracic kyphosis, a painful back and an irreducible deformity (in contradistinction to dorsum rotundum) and is found especially in boys between fourteen and eighteen years of age

As early as 1926 Hanson stated that in kyphosis dorsalis juvenilis the steplike formations at the sites of the future epiphyses in the middle thoracic vertebræ may represent a preliminary stage of juvenile kyphosis He was the first to demonstrate that the disturbances in the zone of ossification are the important factors

Buchman differentiated vertebral osteochondritis from vertebral epiphysitis The former occurs during the first few years of life and is characterized by moderate or slight pain fatigue night cries muscle spasm, tenderness deformity in the form of a knuckle or a generalized kyphosis or scoliosis

The causes of vertebral epiphysitis are found in the following factors (1) infection local and remote, (2) circulatory disturbance in the nature of embolism or thrombosis, (3) trauma, both internal and external (4) glandular disturbances affecting bone growth and development

Buchman stated that an imbalance between the static demand and static capacity is a likely cause of the disturbance This is more apt to occur during the first and second periods of rapid growth

The kyphotic deformity resulting from disturbances of vertebral ossification which occurs during adolescence, is a wedge-shaped deformity of several vertebral bodies

Edelstein expressed the belief that some biochemical disturbance based on an error of nutrition or of assimilation, is at the basis of such epiphyseal affections

Vertebral epiphysitis may cause limitation of motion muscle spasm pain tenderness and sensitiveness to jarring Lateral roentgenograms should reveal the characteristic changes in the epiphysis Roentgenographically, according to Buchman there are irregularity of the vertebral

Lewin's Ten Commandments of Good Posture

I Stand tall, sit tall lie tall and flat
II Walk tall and "chesty"
III Draw in your abdomen, pulling it backward and upward
IV Flatten the hollow of your back
V Roll your pelvis downward and backward and lock your buttocks
Lock your legs together—streamline your hips
VI Keep your shoulders high and square—separate them as far as possible from your hips
VII Hold your head high—chin up and back—eyes straight ahead, as though you were balancing a basket of fruit on your head
VIII Walk with graceful "heel to-toe" rhythm
IX Take the arch out of your back and put it in your foot
X Become posture-conscious



Fig 110 —The spine tells the story A study of this single exposure x ray film proves that with this combination of mattress and springs a person can lie comfortably without distortion of the head and neck shoulders torso pelvis and extremities and be completely supported at every point It proves that he can be comfortable without tension (Courtesy Englander Company)

The differential diagnosis is important from the standpoint of prognosis and treatment The conditions to be considered are tuberculosis, rickets and trauma

The prognosis is excellent, if proper treatment is instituted A residual deformity may be a future source of disability The course is comparatively short, usually ending in spontaneous recovery with regeneration of the affected bone but not necessarily with restoration of vertebral form

Treatment —The patient should be recumbent in bed on a curved Bradford, Whitman or Herzmark frame, with traction applied to the head or legs or both Immobilization is accomplished with a plaster-of-Paris body cast or a spine brace Heliotherapy is beneficial Good hygienic conditions must be maintained Dietetic and vitamin factors are important If glandular disturbances are present, they should be treated All foci of infection should be removed Later, physical therapy, especially posture work, is indicated The clavicular T used in cases of fracture of the clavicle is a useful splint

CALVE S VERTEBRAL EPIPHYSITIS

Calve reported 2 cases, one of his own and one of Bracketts', under the heading A localized affection of the spine suggesting osteochondritis of the vertebral body with the clinical aspect of Pott's Disease " In each case the lesion attacked only one vertebra The lamellar aspect of the osseous nucleus, regular in one case and irregular in the other, and slightly wedge shaped, can be found in Pott's disease, where, however, at least two vertebrae are always affected This cuneiform shape indicates destruction of the intervertebral disk In striking contrast in Calve's lesion the adjacent disks above and below the diseased vertebra were intact The cartilage is thicker *The transparent part above and below the lamellar* osseous nucleus is at least a third higher than normal Greater opacity indicates that the bone density has increased

Allenbach, Wiest and Maure describe vertebra plana osteonecrotica or juvenile osteochondritis of the vertebrae as a rare condition of unknown etiology It has been observed in children only The symptoms simulate those of Pott s disease The roentgenogram reveals a flattened vertebra which is wider in its transverse diameter than its neighbors The condition heals gradually under *immobilization Autopsy* reveals aseptic necrosis of the body of the vertebra

Allenbach, *et al*, reported two typical cases Treatment consisted of immobilization in a cast for 1½ years, followed by a corset

Flat and Plane Osteonecrotic Vertebra (Calve s Lesion) —Iogroscino reported 2 cases of Calve's Lesion in male children of two and a half and three years, respectively Fewer than 50 cases have been reported Clinically, it simulates tuberculous spondylitis the roentgen findings vary In the first stage the involved vertebra melts away and nearly disappears leaving the pedicle with a moderate lamellar appendage and some detritus In the second stage, the vertebra is irregularly flattened and transversely reduced in diameter between disks of normal or greater than normal size In the last stage, the vertebra resumes its former shape and size but without

outlines, flattening and wedging of the vertebræ, which is followed by the stage of restitution, when the vertebral outlines appear dense and sclerosed Deformity of the vertebral bodies is the final result The intervertebral spaces are widened in proportion to the thinning of the vertebral bodies

Roentgen ray Observations —There is wedging of the vertebræ in the thoracolumbar region Schmorl described outpouchings of the nuclear substance into the spongiosa and congenital or traumatically produced orifices in the cartilaginous plate The kyphosis is the result of loss of nuclear substance, which interferes with the physiological state of the



Fig 111 —Vertebral epiphysitis

spine causing failure of enchondral growth in the cartilaginous plate and wedging The excavation disappears normally during the second year of life, except in the lower five or seven thoracic and the 1st and 2nd lumbar vertebræ, where it remains until the age of fourteen years The canal formations may appear in different forms during the ages from two to fourteen years

In some persons the vertebral body has a staircase like outline at its anterior corners The epiphyses are formed in these staircase-like formations Hanson found this type of vertebra in persons with round backs He found the canal formations in all subjects examined in fetuses of 35 cm length and in children up to the age of fourteen years

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DYSOSTOSIS MULTIPLEX

Dysostosis multiplex is a congenital disease characterized by interference with ossification and leading to degenerative changes in cartilage. The active stage of the dystrophy appears to cease as the time of fusion of the epiphyses and diaphyses approaches, but the [illegible] deformities remain as evidence that the dystrophy has existed. The characteristic features are wedge-shaped deformities of the vertebrae, failure of appearance of epiphyseal centers and delay in their ossification, marked shortening of the neck due to cervicothoracic deformity, which also leads to an appearance of a shell-like protrusion of the upper thorax, and marked shortness of the trunk as compared with the limbs. Deformities of the skull are variable

reaching the true shape of the uninvolved vertebra it loses its sclerotic density The onset of symptoms is rather sudden with clinical and roentgen signs, but its course is slow and usually covers from two to four years In most cases only one vertebra is involved, in some first one and later another vertebra is involved The lesion strikes healthy children of from two to ten years of age

Various theories of etiology have been advanced among which the most plausible are the infectious circulatory (trophopathic) and traumatic Mezzari's case revealed at autopsy remnants of bone tissue showing traces of aseptic necrosis while newly formed bone had replaced the vertebral body nearly completely The zones of growth of the vertebral body had remained intact and showed only slight irregularities Compere *et al*, believe that vertebra plana may be due to eosinophilic granuloma

VERTEBRAL EPIPHYSITIS

Nathan and Kuhns in 1940 reported 75 cases of epiphysitis of the spine Roentgenograms showed irregularity of the upper and lower surfaces of the vertebral bodies as the most constant finding Schmorl's islands were seen in twenty-one *The late change was an anterior wedging of the vertebral body* The deformity could be decreased but rarely corrected In adult patients who had received inadequate treatment severe deformity was usually present

INJURIES TO THE VERTEBRAL EPIPHYSES

Injuries to the vertebral epiphyses are usually due to direct blows and especially falls and twists during childhood One of the important consequences is the establishment of vulnerability to mechanical internal derangements of the back during adult life The treatment is rest protection by recumbency cast or brace followed by physical therapy

EXPERIMENTAL RETARDATION OF GROWTH OF EPIPHYSES

Bisgard and Musselman found that in goats (and presumably in man) all growth in the length of vertebrae is derived from the proximal and distal epiphyseal growth cartilages An equal increment is received from each cartilage Excision of the epiphyseal cartilages results in arrest of growth Unilateral excision causes unilateral growth arrest Both experimental and clinical observations of Haas and of Bisgard and Musselman indicate that unilateral retardation of growth of vertebrae is either totally or at least partially responsible for idiopathic scoliosis of man They found that fusion of vertebral bodies with no damage to the epiphyseal cartilages, does not arrest growth

There are two main types of scoliosis: (1) postural or functional and (2) structural or organic.

A postural curve disappears when the patient assumes the recumbent position. A left total scoliosis can be produced by putting a block under the right foot while the patient is standing, or under the right buttock when the patient is sitting. The curve is usually unilateral total and is not accompanied by structural changes in the vertebrae.

With structural scoliosis there is rotation present and there are definite changes in the vertebrae. Carey made an important study of the causes of the subject. His first method included a series of experimental amputations, selective muscle and nerve excisions, and fixation as well as localized injection experiments on young animals with observations on the dynamics of the histogenesis of muscles, bones and joints. The second method was the construction of a working model showing the anatomical and physiological relations of muscle and bone levers of the normal human back. This ingenious model recorded mechanical changes and visualized the normal and abnormal dynamic equilibrium of the musculature of the body as a whole. By this means results of experimental muscular imbalance registered immediately on his spinal indicator, whereas by animal experiments he was forced to wait months and sometimes over two years for the same change to occur.



Carey expressed the opinion that unbalanced action of bilateral antagonistic musculature resulting from undernutrition or malnutrition during the first decade of life will explain many cases of idiopathic scoliosis. He found that there are numerous possible combinations of muscular imbalance. There are 111 muscles directly attached to the movable spine. Carey suggested that superficial muscle imbalance produces deviation while deep muscle imbalance produces rotation.

Mechanisms and Types of Curves. When a spinal column develops a curve it usually is the result of (1) skeletal muscle imbalance, (2) static settling of the spine probably of metabolic origin causing a weakness in the fibrous or supporting soft tissues (idiopathic), (3) asymmetrical growth of hereditary central nervous system origin affecting bones and muscles, (4) malformations of one or more units of the spine.

Under etiologic factors Cobb considers: 1. Idiopathic, which include probably 80 to 90 per cent of all cases seen in a large scoliosis clinic. Of these less than five per cent need surgery.

Fig. 11. This seventeen year old girl had poliomyelitis when she was two years old. Because of the flail right knee with involvement of all groups of muscles, tendon transplantation was not possible and an arthrodesis was performed. When she stood on both feet there was a total right scoliosis, the right gluteal crease was [illegible] inches lower than the left, the dimple at the posterior superior iliac spine was lower on the right, the right iliac crest and anterior superior spine were low, there were three folds in the left iliocostal angle and none in the right. When wood splints were placed under the right foot until it was raised [illegible] inches the pelvis was level and the scoliosis corrected. (Drawn from photo.) (Note: A leg shortening operation was advised.)

CHAPTER 20

SCOLIOSIS, OR LATERAL CURVATURE OF THE SPINE

SCOLIOSIS, or lateral curvature of the spine, is a deformity in which the vertebrae are inclined, in whole or in part, to either side of the median line

Scoliosis has been an enigma to orthopedists for many years Since the time of Hippocrates scoliosis has been recognized and a great variety of treatments have been employed No one ever learned how to successfully treat a single case of scoliosis from a book One must be an apprentice to a man with a big practice

The outlook for structural scoliotics have been greatly improved in the last ten years due to the works of such men as Risser, von Lackum, Cobb Steindler Ferguson Lowman, and Blount The Risser Jacket was the turning point in treatment so far as correction was concerned The Hibbs operation was the milestone in the prevention of recurrence Then the Hibbs operation and bone grafting added the final strokes

von Lackum finds that new horizons have arisen in the non-surgical therapy of idiopathic infantile and adolescent scoliosis, based on studies of the influence of direct pressure on, and mechanical arrest of vertebral epiphysis growth

The Most Important Advances of the Past Two Decades in Relation to Scoliosis are

1 *A revival of serious interest inspired by* the excellent work of Risser, Cobb, von Lackum Blount and Irwin 2 Simplification and Understanding of Etiologic Factors 3 Prognostic Indicators 4 Treatment

A Correction by means of Risser Jacket or von Lackum transsection Jacket B Fusion by means of the basic Hibbs technic and massive bone grafts from the ilium tibia or bone bank

The **etiological factors** in scoliosis involve (1) heredity, (2) congenital anomalies (3) pathological conditions of the vertebrae, (4) nutritional changes, (5) infections (6) epiphyseal changes (7) muscle imbalance (8) inequality in length of legs, (9) paralytic conditions The term 'idiopathic scoliosis includes cases of undetermined cause

In a great many cases the condition is due to anterior poliomyelitis Buchman believed that in many cases it might be due to vertebral epiphysitis

Scoliosis is most frequently observed in girls of school age The curvature is referred to as right or left, according to the convexity, the upper curve is named first, *e g*, a right thoracic, left lumbar scoliosis If a string is drawn from the 7th cervical to the 5th lumbar spinous process, the curve begins and ends where it passes under the string The curvature may be simple, a C curve, or compound, an S curve triple curves also occur

EXPERIMENTAL RADIATION SCOLIOSIS

Arkin and Simon claim that direct unilateral suppression of epiphyseal growth can be controlled to produce wedging in a predictable area.

Structural scoliosis can be produced in the spines of rabbits by irradiating the vertebrae asymmetrically.

The resulting unequal bone growth yields wedging of the vertebral bodies with the lesser height toward the irradiated side. Engel induced scoliosis in young animals by placing radium needles on one side of the vertebral column.

The concavity of the scoliosis was toward the more heavily irradiated side. Curvature of the spine in young animals has also been induced by roentgen rays.

The isolated lumbar curve follows the field of radiation and the wedging is directed toward the irradiated side.

The Cure of Experimental Scoliosis by Directed Growth Control

Correction was accomplished by clamping together the vertebrae in the primary curve on the convex side.

Pathological Changes. The spine, a flexible weight bearing column made of segments and already physiologically curved in its anteroposterior plane, will not yield in the lateral plane without rotating and twisting. In this twist the bodies of the vertebrae must turn away from the greatest weight and pressure, i.e., toward the convexity, while the spinous processes rotate away from the convexity. The anterior portion of the spine is distorted more than the spinous process. In rotation the greatest change in the position of the vertebrae takes place at the center of the part entering into rotation; in torsion it takes place at one or the other end of the spine. The abdominal oblique muscles are the stabilizers of the rib cage which enable it to swing laterally whenever the arm and shoulder girdle muscles and the leg and pelvic muscles produce an asymmetrical pull which gives rise to a rotary spinal deviation. The pull in one direction of the serratus posterior inferior, which is the chief opponent of the abdominal oblique and opposite transversalis colli, may be the stabilizing influence against this side twisting.

Risser believes that progressive scoliosis is a problem of vertebral growth and results from asymmetrical epiphyseal pressure. He finds that excessive vertebral rotation is a concomitant part of lateral bending of the spine. In the lumbar region, the lateral bend is manifested by early rotation and later wedging, whereas in the upper thoracic region lateral curvature is manifested by early wedging structural changes and later rotation, thus making it more difficult to correct the deformities in the upper thoracic spine.

He believes there is a direct relationship between the increasing scoliotic deformity and (*a*) Rapid vertebral growth, (*b*) Poor bone integrity, (*c*) The severity of the curvature. Completion of vertebral growth is determined by a physiological sign which is manifested in the iliac apophysis.

Von Lackum described the following curves:

Primary Curves.—In triple patterns of deformity the middle curve is always the primary curve.

2 Post polio, probably 5 to 10 per cent, 50 per cent need operation
3 Neurofibromatosis, less than 2 per cent all need fusion
4 Thoracogenic, such as post empyemic, post thoracoplasty, less than 2 per cent, need operation
5 Osteochondrodystrophy, Morquio s Disease, less than 1 per cent
6 Congenital, less than 2 per cent, need operation depending on the severity Most hemivertebra if single, require little treatment
7 Friedreich's Disease, less than 1 per cent
8 Spastics, few need surgery

Structural scoliosis may be due to bone, nerve or muscle lesions, or to unknown etiology Measurements of the angle of the curve are important Measurements of the wedging and measurements of the rotation should be made

Steindler emphasizes compensation He started with "correction but now comes back to "compensation'

Compensation is the development of counter curves so that realignment occurs between the occiput and pelvis If one observes a round hollow back and both curves are of equal length and of equal angular value, they are compensated

Cobb emphasizes the importance of careful follow-up and study of children during the period of possible progress in the curve He also stresses the importance of early recognition The study and treatment of scoliosis is a very complex problem and each patient must be considered an individual problem and studied accordingly Therefore it is impossible to lay down strict rules

Scoliosis is very frequently overlooked until it is quite severe Most curves are at least moderately advanced when first noticed, especially on the x-ray Scoliosis should be looked for in every routine physical examination Every child between six and sixteen years should have a routine spine examination every six to twelve months Polio patients frequently develop scoliosis unobserved by the orthopedist Photographs and posturegraphs are valuable to show others and to watch the progress X-rays made in the standing sitting and supine positions are of great value Films should be repeated every three months if the curve is increasing All x-rays should show the entire iliac crests

EXPERIMENTAL SCOLIOSIS

THE ROLE OF THE EPIPHYSES

Nachlas and Borden produced a human-like scoliosis by experimental control of epiphyseal growth

They observed a group of animals in whom a fixed lateral curvature has been corrected by applying operative growth control If this process can be applied to scoliotic children it offers hope for cure of the condition Though the human subject presents greater technical problems than animals the difficulty is not insurmountable Nachlas and Borden have applied the same technic to children, who are being carefully studied for the effects of selective growth control

In quadruple patterns of deformity the two middle curves are the primary curves (double primary).

Single curves predominant as a single primary curve in the right thoracic area; this triple pattern of deformity occasionally deviates to the left and appears additionally over varying anatomical regions of the spine.

Double curves usually occur as right thoracic left lumbar curves extending over the relative total area Th5 to L5. When extending over the respective anatomical areas Th5 to Th11 and Th11 to L5 their comparative values are equal.

Irwin classifies paralytic curves as follows:

1. Lumbosacral scoliosis with a fixed pelvic obliquity.
2. Lumbosacral scoliosis with the pelvis a part of the curve, i.e., a scoliotic pelvis.
3. Long C curve involving the thoracolumbar region.
4. Thoracolumbar curve with the thoracic segment the primary or fixed curve.
5. Thoracolumbar curve with fixation in both the thoracic and the lumbar segments.
6. Cervicothoracic scoliosis and kyphosis.

Symptoms and Signs. The distortion is manifested by a high shoulder, a prominent hip or a prominent shoulder blade. Impaired thoracic function may produce shortness of breath or a rapid heart. When the condition is extreme the ribs may rub against the crest of the ilium or be found below their usual level. Pain is then located at the lowermost portion of the costal margin near the crest of the ilium, being produced by pressure and irritation of the 11th intercostal nerve. Moe collected 22 cases of paraplegia due to scoliosis.

Physical Examination. — The entire dorsal surface of the body must be bare. The first consideration is symmetry. If the torso is not symmetrical, it can often be made so by raising one leg or by placing the patient in recumbent position. The levels of the gluteal creases, shoulders and scapulae are observed. The symmetry of the iliocostal angles is noted. The position of the head and the normal curves of the back are observed. The lengths of the legs are measured. The posture of the feet should be noted. The rhomboid of Michaelis, i.e., the diamond-shaped depression formed by the dimples at the posterior-superior spines of the ilium, the lines drawn by the gluteal muscles and the groove at the end of the spine are studied. If this rhomboid is outlined while the patient is standing, the vertical axis should be parallel with the long axis of the body (see Fig. 112).

In side bending, flexibility is greater toward the side which makes the curve worse.

SPINE BALANCE VS. TOTAL BODY BALANCE

Von Lackum finds a significant difference between spine balance and total body balance. Clinical body balance and equal avoirdupois hemibalance, though similar, are likewise quite different. The former is perfect balance comparable to balance on the point of a pin, whereas clinical body balance is relative balance on a base the width of the standing position of one's

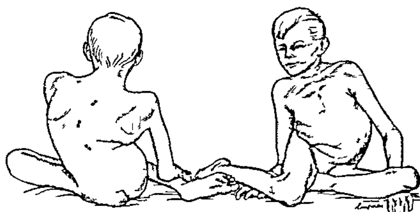


FIG 113 —Severe scoliosis due to infantile paralysis This child was denied medical care by his parents (Redrawn from photographs) (Lewin's Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

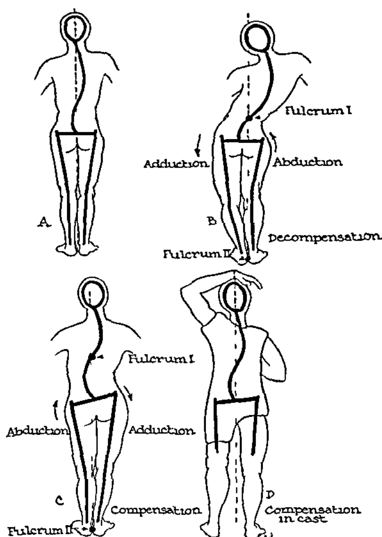


FIG 114 —Diagram illustrating stages in the compensation phenomenon of scoliosis *A* Scoliosis *B* decompensation *C* compensation *D* compensation in cast (After Steindler Hamsa and Cooper)

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two feet Clinical body balance therefore is balance which may have, but does not require, avoirdupois hemibalance, as is shown by body balance being present in those with a scoliosis shift of the trunk, as well as in those with a normally straight spine

A vertical line passed up from the first sacral spine will either pass directly through the external occipital protuberance of the skull, in which instance the pelvis and shoulders will be in line (referred to as central midline balance) or it may pass laterally to the protuberance, in which instance the trunk will be out of line with the pelvis—a position of eccentric balance

Pelvic tilt Roentgenogram —The patient sits on the edge of a table which is sufficiently high to prevent his feet from resting on the floor His hands are in his lap, giving no support to the trunk The pelvis is now raised on the side of the convexity of the lumbar curve by the pushing of flat objects such as boards or books, under the left buttock A point will be reached where the patient is tilted so far toward the right that a loss of body balance is threatened, and falling to the right is imminent If the patient is now asked to straighten up from this position he can do so only by straightening the lumbar curve If this is possible, this is a secondary curve With the subject attempting to sit straight, an antero posterior roentgenogram is taken of the spine from the 1st sacral vertebra up Measurement of this lumbar curve as compared with the lumbar curve in the standing view will give the answer to the problem This is Ferguson's method of determining the primary curve and the number of vertebræ to be fused

Recording Methods —Every patient should be photographed through a screen after the spinous processes have been outlined and a plumb line dropped from the cervical vertebræ The patient should stand A schematograph or silhouettograph is useful for making permanent records The standing roentgenogram is the best record

A roentgenogram of the whole spine assists in determining the type of the curvature and the degree of rotation or torsion it reveals congenital anomalies and in some cases suggests where the primary curve appeared Roentgenograms should be made in the antero-posterior and lateral projections while standing, sitting and recumbent The roentgenogram is the most reliable means for recording the progress of the disease and the results of treatment

I am indebted to Dr Joseph Risser for a very simple celluloid protractor which is used in measuring scoliotic deformities on the roentgenogram The most severely rotated vertebral body is centered and dotted The two least rotated vertebræ at the ends of the curve are centered and dotted The junction of the arms of the protractor indicated by the small central opening is placed directly over the dot of the most strongly rotated vertebra at the center of the arm The two arms then are placed over the dots at the ends of the curve The supplementary angle is then read in degrees That angle is formed by one arm of the protractor and an extension either upwards or downwards of the other arm Other protractors were designed by Freiberg Ferguson and Cobb

Diagnosis —The important considerations in diagnosis are whether destruction of bone is present as in tuberculosis and in children whether developmental anomalies or nutritional or infectious disturbances are factors

Heyman found that spinal cord compression complicating scoliosis occurs in long-standing cases

Prognosis —The prognosis depends on the type and severity of the curvature, its cause and its duration, the rigidity of the soft tissues of the trunk, the general health of the patient, the kind of treatment and the persistence of the doctor and the patient

According to Risser, a structural curve may increase in severity during the period of rapid growth Compensated curves tend to remain stationary beyond the period of vertebral growth, in boys about sixteen or seventeen, in girls about fifteen Completion of growth of the epiphysis of the crest of the ilium in the roentgenogram is a favorable sign

Scoliosis Usually Becomes Static with the Completion of Vertebral Growth — Although the average chronological age at which vertebral growth stops and the scoliosis becomes static is fourteen in females, the extremes extend from twelve to nineteen years Risser uses a physiological sign The completion of ossification excursion of the iliac apophysis has been proven to occur simultaneously with the completion of vertebral growth and with it the curvature becomes static

Prevention of increasing scoliotic deformity with correction without surgical immobilization is an important factor in the treatment of scoliosis

Risser sums up the following points

1 If one knows whether or not a scoliotic deformity will get worse, he can make satisfactory disposition of the case

2 by spinal fusion one can prevent increasing deformity or maintain correction,

3 maximum correction can be obtained by a turnbuckle cast,

4 in early cases when the condition is still reversible the application of Hueter-Volkmann's epiphyseal pressure rule (bending against the curve and holding in a physiological position) prevents an increase in deformity and in very early cases, this correction can be maintained

5 by paying adequate attention to nutrition (avoiding of heat-processed and refined foods) the incidence of scoliosis may possibly be prevented

6 the term "metabolic curve" should replace "idiopathic curve"

Delayed and fragmented epiphyseal plate development is more noticeable at the apical vertebra indicating local trauma plus systemic changes which allow this change to occur This characteristic epiphyseal change is found in a large majority of scoliotics These cases invariably had a lowered metabolic rate and an elevated blood cholesterol Two factors strongly suggest that these changes are due to dietary deficiencies

The Hueter-Volkmann rule —With the proper external support a force could be controlled in the presence of vertebral growth by complete overcorrection or reversal of the force causing the change in bony development

Prophylactic Measures —Prophylaxis should be instituted during the pre-scoliotic period The most important prophylactic measures are the prevention and the adequate follow-up of conditions leading to bone and muscle imbalance during the period of growth especially in poliomyelitis, chest infections and long-continued illnesses

Attention must be given to the desks and seats at school to defects of the eyes and ears and to the avoidance of fatigue The nutritional require-

ments during the period of active growth should be taken care of Special exercises are prescribed for strengthening the musculature and for equalizing the range of lateral motion on both sides of the spine "Crawling" exercises and underwater gymnastics, including asymmetrical swimming, are valuable Imbalance of the pelvis from any cause should be corrected by modifications of the shoes The degree of elevation can be estimated by placing graduated lifts under the heel on the side of the convexity until the spine is straight

Conservative Treatment —Cobb finds that rest and recumbency are the only significant conservative measures Few if any braces have ever proven to give adequate control of the progress of a curve The Milwaukee brace appears to be the best Plaster jackets rarely control the curve or prevent progress if the patient is erect Exercises do not prevent the increase in the curve if the curve is increasing Seldom if ever do they appreciably decrease the curve permanently They do however improve the muscle tone, the vital capacity the appearance the posture and health, but they do not alter the progress of the curve If the curve is increasing one must consider either correction and fusion or emphasize position up to twenty-two hours daily with two half-hour exercise periods in the morning and in the evening

Active Treatment —In moderate and severe types of scoliosis in addition to exercises, severe stretching by hand, apparatus or corrective jacket is essential One must be prepared to hold the torso in some efficient apparatus

Bradford, Whitman and Herzmark Frames —The patient is placed on a curved gas pipe frame and maintained in position for several weeks In addition head or pelvic or lateral traction may be used This permits muscle spasm to diminish

Hoke designed a corset made of double layers of coutil reinforced with whalebone and aluminum-steel stays

Steindler attempted, by special exercises, to curve the spine above and below the scoliotic area in order to produce compensation Then, if the back was stable, he prescribed a brace, if the back was not stable, he performed a fusion operation He expressed the opinion that realignment of the spine by compensation attains a satisfactory degree of body symmetry and proper redistribution of weight without relaxation of the spine, and that spines subsequently stabilized by operative means are, by virtue of their realignment by compensation without relaxation in a better position to be maintained in a state of stability than those operated on while in state of decompensation

Compensation-derotation plus adequate muscle development promises success for the majority of non-paralytic deformities

A study of the sequence of events in scoliosis determines the plan of treatment Obliquity of the pelvis must first be corrected Any fixed contractural inequality must be corrected by traction or release of the muscular contractures The leg lengths must be equalized When there is a translatory shift of the pelvis the pelvis and spine must be realigned by the compensation methods producing a countercurve This phase of the treatment is employed only when the primary curve cannot be straightened

by traction or corrective side bending. When compensation has taken place the scoliosis involves only the spine and the trunk rests squarely on the pelvis. For patients who later come to fusion, compensation is most essential.

Experience shows that the high percentage of failure of the spine to maintain its position after fusion operation, occurred when a decompensated spine was fused.

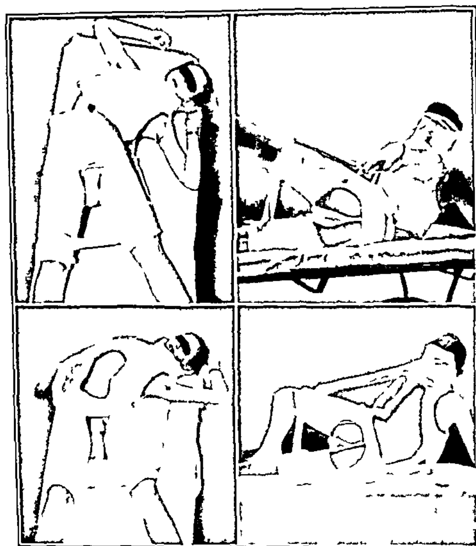


Fig. 115.—Risser bent jacket cast correcting paralytic scoliosis preparatory to spinal fusion. Note hinge and turnbuckle. The operation is performed through a window in the cast. (Lewin's Infantile Paralysis, courtesy of W. B. Saunders Company.)

Correction of the lumbar curve by derotation removes the danger of collapse of the lumbar spine. Fixation is maintained either by muscular effort or by fusion. As the collapse of the spine takes place under rotation and lateral bending, the first concern is to maintain the compensated or realigned spine by traction in bed or with an adequate brace, which will maintain the realignment and relieve the spine of the superincumbent weight.

In many cases elimination of the lumbar curve and fusion of the thoracic curve are sufficient. Lateral bending of the curve is easily carried out after derotation and the corrected position readily maintained by a plaster shell. Once correction is attempted with casts, the operator should decide to perform a fusion operation.

Hibbs-Risser Traction Jacket.—The Risser method is probably the best means of correcting a scoliotic spine. A plaster jacket with a head piece is applied with the patient in the supine position on a horizontal frame under head and pelvic traction. Hinges are placed front and back over the crests of the curves, and turnbuckle lugs are placed on the side of the concavity and incorporated in the jacket. A double hip spica cast is attached. This distributes the grasp on the pelvis and allows a wider opening over the convexity of the curve. It may be omitted in treating high thoracic curves. The patient is placed on a special frame. During application of the jacket the subject is under strong traction on the head and countertraction on the pelvis by means of a traction belt secured above the iliac crests. The muscles of the back relax and yield more quickly to longitudinal stretching.

After from three to five days, the jacket is cut through between the front and back turnbuckle lugs to the points of motion of the hinges. On the opposite side of the jacket at the level of the hinges a window is cut out so that bending can take place. Correction is obtained through gradually bending the jacket to about 90 degrees by means of the turnbuckle. The bending requires from one to two weeks. After bending, all new pressures must be relieved. The jacket is now reinforced by struts made of basswood splints wrapped in plaster. The turnbuckle is removed. The back of the jacket over the area to be operated on, including the posterior hinge, is removed. Because of the extreme bending, the opposing curves are localized as closely as possible to the crest of the curve under correction. The fusion area-to be includes as much of the opposing curves as is necessary for compensation, and extends from a vertebra at the upper end of the corrected curve whose superior surface is parallel to the inferior surface of a vertebra at the lower end of the curve. The skin is marked with silver nitrate over the spine of a vertebra in the proposed fusion area, a lead arrow is placed over the mark and a roentgenogram made. The marked vertebra is then identified, and the skin mark is used as a guide at operation.

Fusion is done through a posterior window of the cast, to prevent loss of correction. It is accomplished in short segments at two or three operations if necessary. The patient continues in the corrective jacket for three months until the fusion becomes strong enough to withstand stresses. On its removal a semi-bent jacket is applied without traction to allow the body weight to thrust through the convex side of the curve. This is removed in from three to nine months making from six to twelve months of postoperative support. While the patient is in the semi-bent jacket and after its removal symmetrical exercises are utilized to improve the posture and general muscle tone.

LeMesurier places the patient on his side in a net hammock and the two ends of the hammock are slung up to the ceiling, with the body bent sharply in a direction to correct the primary curve. He is placed in the

hammock for an increasing length of time each day until he becomes used to the best position. While he is hanging in the hammock in this position a plaster is applied which extends from the head to one foot. A window is cut in the back of this plaster and the patient is ready for the fusion operation.

Galeazzi's Method.—Galeazzi obtained correction in cases of severe rigid scoliosis as follows. The patient is placed under an intensive preparatory mobilizing treatment. The deformity is corrected by means of an apparatus consisting of two independent units, one of which secures the shoulder girdle and the other the pelvic girdle.

The patient is placed on a raised platform within the apparatus. The apparatus permits independent rotatory movement of the two end-units

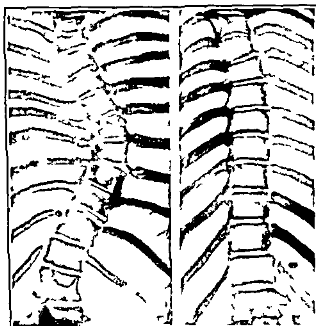


FIG 116.—Roentgenograms of patient with rigid structural scoliosis corrected in Galeazzi apparatus. (Courtesy of Professor Galeazzi.)

around a vertical axis which accomplishes lateral deflexion of the spine. It also allows rotatory movements around the longitudinal axis of the spine producing derotation and detorsion.

The spine is secured at its two ends by the application of two plaster-of-Paris sections, including the pelvic and shoulder girdles. With a three-tailed bandage applied over the apex of each curve and held by an assistant so as to act as a fulcrum, one slowly begins to correct by means of deflexion and derotation against the fixed shoulder and pelvic girdle sections. These are then united by the third plaster-of-Paris section. The cast extends from the points high on the shoulders to other points below the great trochanters. Windows are cut out over the concavities of the curves. When the cast is complete the patient stands in a flexed position and walks with his body flexed toward the convexity. The casts are changed every three months. The total duration of the cast period is from eighteen to

thirty-six months The chief virtues of the treatment are its correction by deflexion and derotation rather than by means of a direct force The key to the correctibility of the spine lies in a long preparatory mobilizing treatment

At the Chicago 1952 meeting of the American Academy of Orthopedic Surgeons Risser demonstrated the *Application of Three Types of Body Casts* Since lordotic spinal curves are gravity-induced, Risser calls them gravity curves A cast which opposes these gravity-induced curves is called an anti-gravity cast It was first used in 1936 to correct poor posture, wedging round back low back pain and compression fractures of the spine

To correct the lordotic lumbar spine the patient reclines supine on the sagging hammock-like canvas sling attached to a plaster frame The head and shoulders relax on a removable back rest

The cast is applied in two sections The pelvic section is molded at the lower abdomen with a 4" triangular block When the pelvic plaster is set the back rest is removed and the patient hyperextends the midthoracic spine over the pull-out bar to which the canvas sling attaches Pressure over the pull-out bar is softened by the use of felt and two curved metal straps which are removable

In this position the thorax is elevated and the upper portion of the cast is applied with care to avoid compression of the lower ribs The patient is removed from the canvas sling and the plaster frame, after the frame and patient have been lifted from the frame supports to a table

Correction of lateral curvatures is accomplished by a combination of parallel head and pelvic traction with lateral bend or posterolateral pressure or both This combination of forces is termed 'oblique traction It was used by Guerin in 1842

Lateral bend of the spine with parallel traction attempts to align the ends of the curve over the apex This force is used in the AP hinge turnbuckle cast used first at the New York Orthopaedic Hospital in 1927 The cast is applied with the patient supine on a slightly sagging canvas sling maintaining the physiological relationship of the abdomen and thorax Head and pelvic traction is applied to lessen the secondary curves tending thereby to incorporate them with the correcting curve into one large C' curve The hinges are placed eccentrically and superimposed over the apex of the correcting curve A window is removed from the plaster over the apex of the curve The cast is sectioned from the point of motion of the hinge to the concave side where a turnbuckle is inserted Lateral bending with traction is accomplished by the use of the turnbuckle, gaining correction of the lateral curve by superimposing the ends of the curve over the apex

A more accurate application of oblique traction is accomplished with the "localizer cast The object of this is to place the apex of the correcting curve in line with the ends of the curve thereby gaining alignment of the spine

The localizer cast is applied with the patient lying supine in a physiological body position on the canvas sling attached to the plaster frame Posterolateral rib angulation pressure is obtained by the use of jack screws sliding on a metal half circle frame suspended from the sides of the plaster frame under the patient Pressure over the rib angulation is softened by

the use of a small metal platform placed on the end of the jack screw. This removable metal platform presses against a thick felt pad over the rib angulation.

Correction is obtained before the application of the "localizer" cast. The cast is then applied in the corrected position. To gain maximum correction, one or more casts may be necessary in severe scoliotics. Correction of two curves simultaneously may be accomplished by using two localizers. Ambulation may be started two or three weeks after surgery.

The Milwaukee Brace.—The Milwaukee brace was developed by Drs. Blount and Schmidt as a refinement of the distraction or transection plaster jacket. As an adjunct to surgery, the patient wears the brace before operation only long enough to become accustomed to it. Correction of the primary curve is accomplished after the operation has released the contracted muscles and ligaments.

The brace has been used in the conservative treatment to postpone the need for operation (particularly of the paralytic curves). It will reduce the primary curve and slow the progress of the deformity in some cases. It is more effective when the patient is supine but it may be worn as an ambulatory brace. Occasionally it is used during the last year of the growth period to obtain an acceptable permanent result without surgery.

The efficient forces of lateral pressure and distraction have a reciprocal relation. In the severe curve, distraction is much more efficient; in the mild curve, lateral pressure.

In the conservative and operative treatment of scoliosis, it is important to think of posture, health and function of the patient and not merely the straightening of curves as seen in the x-ray. As a general rule in the uncomplicated case, it is advisable to fuse not less than the primary curve, unrotated vertebra to unrotated vertebra. The operation should include meticulous fusion of the facets, overlapping of attached autogenous slivers from the laminae, the addition of a small amount of bone from the ilium (or the bank in children). It is unwise to fuse unnecessarily when the patient is too young. In some cases, the Milwaukee brace may be used to postpone operation until the child has reached a better age. It is also unwise to neglect the patient so that he develops disastrous, irreversible changes.

In the past, the difficulties associated with the correction and fixation deterred most men from attempting the operative treatment except in the most severe cases. The Milwaukee brace relieves the surgeon of the chore of making a huge operative cast. It is more comfortable for the patient and removes some of his objections to the operation. It eliminates the contra-indication to operation on scoliotics in hot climates.

With the method of correction and fixation simplified, it is logical to operate earlier on the progressive curves and thus diminish the duration of treatment and the ultimate deformity for a larger number of children.

Various operative methods have been devised for immobilization of the spine, those of Hibbs, Albee, Risser and others. My own method is that of Hibbs plus the insertion of osteoperiosteal and chip grafts. If the patient is physically strong, a complete Hibbs fusion is done. If the patient is not strong, the surfaces of the laminae are not osteotomized. In either case,

two osteoperiosteal grafts taken from the tibia are placed, one on each side, over the laminae. Albee's operation is the same as his procedure for tuberculosis modified to meet the altered contour of the spine.

Irwin believes that the treatment of rapidly progressing high thoracic or cervico thoracic curves with beginning "razor-back" deformity in young children presents the greatest challenge to the skill and ingenuity of the orthopedic surgeon.

Compensation and body symmetry should be the targets of all treatment. This is accomplished by rotation and wedging in sequence.

Fusion Operations — There are at least four types of scoliosis in which fusion should be done (1) uncontrollable scoliosis resulting from anterior

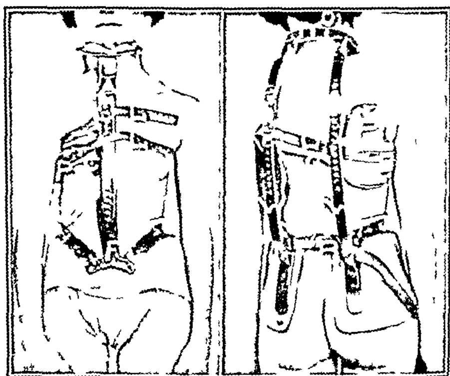


Fig 117 — Blount Milwaukee Brace

poliomyelitis (2) marked and increasing scoliosis in adolescents (3) painful scoliosis in adults (4) congenital deformity. If iliocostal impingement is pronounced resection of the distal ends of the lowest ribs is recommended.

Cobb warns against fusion too early with the fear that lordosis will result especially if fusion is done when the patient is very young. He tries to avoid fusion if the back is flat or abnormally convex until the patient is *well grown such as age thirteen to fifteen. A round back may be fused earlier.* It may be necessary to try years of prolonged bed rest traction plaster jackets turnbuckle jackets or braces to delay the time of fusion. Some curves increase in spite of all these measures.

If in spite of all conservative treatment including intermittent turnbuckle jackets the curve is progressing rapidly one may be forced to perform a fusion earlier than he wishes.

Stabilization is often more important than cosmetic improvement in postpolio scoliosis. It is important in cases of severe pelvic tilts where the ribs are in the pelvis, viscera displaced and the ureters compressed with renal stasis, infection and calculi. Probably 40 to 50 per cent of polio scoliosis cases need fusion. Many polio curves become stabilized and static. Cobb advises that the greater the muscle imbalance, the more need for a massive mature fusion.

Cobb uses the maximum amount of bone. He employes donor bone or bank bone in order to obtain an adequate fusion mass. After the fusion mass is completely mature, which usually requires twelve to fifteen months, no further support should be necessary.

In idiopathic scoliosis, which group constitutes 80 to 90 per cent of all scoliosis problems, less than 5 per cent can be benefitted by spine fusion. Most idiopathic scolioses stop progressing spontaneously at, or about the age of fifteen years. It is difficult to prove that any specific treatment stops the progress of a certain idiopathic curve. It may have stopped spontaneously.

Most idiopathic curves are multiple structural curves. One must balance the corrected curve with the opposite one either present or anticipated, if correction and fusion is planned.

Cobb believes that very mild curves do not need fusion but that the very severe ones do need it, if correction is obtainable and permissible.

Cobb's Technic of Spine Fusion for Scoliosis.—Most fusions for scoliosis are in the thoracic area where there is more stability and a better mechanical situation for a successful fusion. There is more bone locally for bridging the intervertebral spaces and the bone is usually good material for healing and repair. All Cobb's patients are immobilized in plaster jackets in a corrected position with the facets on the convex side forced tightly together by the preoperative correction in the turnbuckle jacket, so that, in the postoperative period of bone healing these scoliosis patients have the best immobilization of any group of patients selected for spine fusion.

A successful fusion depends on a combination of factors:

(1) Good surgical technic.
(2) Sufficient amount of good bone.
(3) Immobilization.
(4) Time for maturity of fusion mass.
(5) Local and general bone metabolism.

Cobb has poorer results and more pseudarthroses in neuropathic scoliosis cases, such as a polio case, than in other groups. Many polio cases are more unstable, with involvement of the unstable lumbar area of the spine more frequently, have poor local bone conditions, often with small stubby spinous processes, wider intervertebral spaces to bridge and, when tibial bone was used, it usually came from small atrophic spindly tibias. Many of these patients were older, and postoperative immobilization was more difficult and poorly tolerated.

From the point of view of fusion, scoliosis cases may be divided into the stable and the unstable types.

1. Stable scoliosis includes most idiopathic and nonparalytic types, though some paralytic cases are also stable.

two osteoperiosteal grafts taken from the tibia are placed, one on each side over the laminae. Albee's operation is the same as his procedure for tuberculosis modified to meet the altered contour of the spine.

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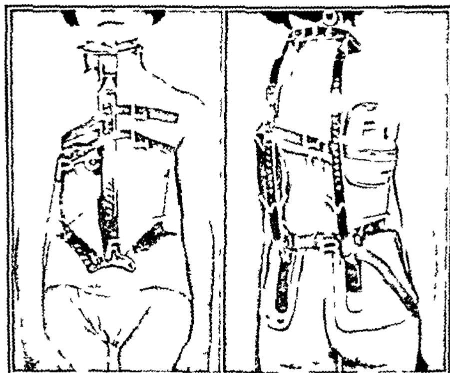


Fig 117 Blount Milwaukee Brace

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piece of straight heavy wire is then fastened with adhesive tape to the skin transversely over these methylene blue marks and an x-ray is taken centering over the markers. If the x-ray shows the metal markers to be over T4 T5 or T6 and T11 T12 or L1 respectively, it does not matter, so long as it identifies spinous processes at or near the end vertebra in the fusion area. It is then possible at the time of operation to note that the fusion area is T5 to T12, the markers being on T6 and T11 for instance, and thus by identifying these two vertebra one can be fairly sure of fusing the selected area T5 to T12.

Cobb's Operative Technic – The area of the fusion is located by means of the methylene blue markers in the skin. Scratches or colored marks are made on the skin just below the lowest spinous process and above the top one to be included in the fusion. Using a straight edge (Steinmann pin) a straight line is drawn from these two points to indicate the skin incision. The methylene-marked spinous processes are then localized by cutting into them through the skin and down into the spinous processes, in the line drawn for the skin incision.

After these spinous processes are identified the straight skin incision is made, adding to the cosmetic improvement instead of drawing attention to the residual uncorrected curve by making the incision directly over the spinous processes.

The spinous processes and laminæ of the vertebræ to be fused are then exposed subperiosteally with sharp periosteal elevators.

Starting at the most dependent part of the wound (so the blood will run down over the completed area and not over the part being gouged), long thin spicules of bone are turned down from the spinous processes and locked under laminal chips on the vertebra below. These spinous-process slivers are on the inferior lateral angle of the spinous process and are left intact at the base so that like greenstick fractures they may be more rapidly revascularized than if they were detached completely.

Similar long thin slivers are then turned up from the spinous process below and locked under laminal chips of each vertebra above. At least four slivers are turned down over the space below and up over the space above. Thus as many interdigitating spicules as possible are turned across each interlaminal space and locked under the laminal chips of each adjacent lamina.

The plan is to have as many as possible of these small flexible slivers of living bone still attached at their bases crossing the adjacent interlaminal spaces and locked under laminal chips still attached at their bases.

This procedure should be done as if no other bone were available and Cobb depends chiefly on the local bone for a successful fusion. The lower half of the spinous process at the bottom of the fusion area is left intact, with its interspinous ligament to the spinous process below undisturbed and similarly at the top. This permits a normal relationship of the fused area to the vertebræ above and below when the finally solid fusion area becomes a single vertebral segment.

When this is completed a neurological clip is placed on the remaining half of the spinous process of the top and bottom vertebræ in the fusion and the supplementary bone (tibia, iliac, donor or bone bank) is added

2 Unstable scoliosis includes many of those due to polio and other neuropathic conditions

The aim of spine fusion for stable scoliosis is primarily to maintain the correction obtained preoperatively In unstable scoliosis one desires stabilization as well as maintenance of correction In most lumbosacral and other short fusions the object of the fusion is to obtain stabilization and prevent motion The fusion for scoliosis must be more massive and mature than in fusions for most other conditions

Cobb mentions a few important points about selection of cases Most scoliosis patients selected for fusion are between the ages of twelve and sixteen years The best age is some time at or shortly *before cessation of* growth about thirteen and a half to fourteen and a half for girls and fourteen and a half to fifteen and a half for boys In some cases because of severe deformity or rapid progress fusion should be done earlier If there is already a flat or lordotic thoracic spine with less than average anteroposterior diameter of the chest, early fusion should be avoided, if possible Conversely if there is a concomitant kyphosis and increased anteroposterior diameter of the chest, earlier fusion is often desirable

Indications for Operation — There are many indications and contraindications for operation and good results depend on a careful consideration of these Fusion is not desirable if the curve is mild stable and unprogressive It may not be desirable even when the curve is severe if the opposite curves are severe enough to permit little, if any correction It may also be contraindicated because of physical psychological and other reasons

Preoperative Correction of the Curve —Cobb considers the modified Risser turnbuckle plaster jacket the best method of correcting the most difficult cases

Bending the patient to the side of the concavity of the curve during application of the turnbuckle jacket permits maximum correction of the major curve with minimum increase or actual decrease in the opposite curves during the many months of postoperative immobilization

General Operative Considerations —These patients should have good preoperative study and care It is desirable to plan the correction and operation so that these procedures can be completed before the arrival of the hot weather In very hot weather the patient s temperature may go to 105° during the operation and produce the complications of heat reactions and salt loss

A good operating team, with surgeon and assistant accustomed to working together, good anesthesia, adequate blood transfusions and gentle surgical technic make it possible to do rather extensive fusion areas even on frail patients with little fear of surgical shock

Cobb s Localization of the Fusion Area —Successful results in the operative treatment depend on the accurate localization of the fusion area It is absolutely essential to have preoperative markers and x ray studies to localize the exact area and levels to be fused This is done by injecting a drop of methylene blue intradermally exactly over the spinous process of the top and bottom vertebræ selected for the fusion area For example if the fusion is to be done from T5 to T12 the methylene blue should be injected intradermally over the spinous process of T5 to T12 A one inch

by division of the eighth, ninth and tenth ribs After insertion of one staple a roentgenogram is obtained to verify the level of insertion Three staples are then inserted across the intervertebral space of each of the intervals between the eighth ninth, tenth and eleventh thoracic vertebral bodies Two staples are inserted across the space between the seventh and eighth and eleventh and twelfth vertebral bodies, making a total of thirteen staples

Von Lackum discussed the new approaches of trans-thoracic stapling and of intra-thoracic multiple partial hemi-vertebrectomies (concave side epiphyseodesis)

Osteotomies and recorrection of recurrent operative deformities showing solid fusion are practical procedures Early recognition of lost correction pseudarthrosis and immediate recorrection prevent the late union which makes osteotomies necessary Full and sustained recoveries of lost correction are thus required

Von Lackum outlines in detail the specific designations of areas to be fused under the categories of

1 Single primary curves
2 Double primary curves
3 Congenital anomalies

Risser finds that a scoliotic deformity is best corrected by oblique traction that is, lateral bend plus parallel traction Surgical immobilization will maintain the correction previously gained and will prevent increasing deformity In early cases the deformity can be prevented and some correction maintained even without fusion by reversing the epiphyseal pressure This is accomplished by the anti gravity cast which incorporates a lateral bend

By reversing the force causing lateral curvature, and bending the spine laterally against the curve, Risser claims that both curvature and rotation are corrected

Therefore in order to maintain correction of the scoliotic deformity all mobility of the corrected area must be eliminated By eliminating the motion in the spine through which the deformity occurs no increase in deformity will take place

The fusion area should cover the entire area of the curve that is from the neutral or least rotated vertebra above to the neutral vertebra below In the x ray showing correction these vertebra should be parallel If compensation is required for a residual or uncorrected deformity fusion should be carried one or possibly two vertebræ into the opposite curve This should not be done if there is sufficient structural deformity in the compensating curve Otherwise the severity of the compensating lumbar curve is maintained and the subsequent relaxation of the compensatory curve does not occur If the fusion area is short and does not include the full extent of the curve recurrence of the deformity will occur

The most important thing to know about scoliosis is to be able to answer the question will my curve get worse Risser finds that this is made possible by knowledge of the physiological age as indicated by the development of the iliac apophysis This growing bone center first becomes visible on the anterior aspect of the crest of the ilium and during the following year

(NOTE Cobb's enormous bone-bank grafts look like a heaping platter of French fried potatoes)

It is desirable to add as much bone as possible, and still be able to close the periosteum and muscles over the fusion mass If an osteoperiosteal strip is used, a button hole can be made at the top and bottom to fit over the remaining half of the spinous process at the top and bottom

The wound is usually closed in three layers, muscle, subcutaneous tissues, and skin

After operation the patient should be turned at least every two hours and as soon as possible encouraged to do deep breathing Exercises for the extremities are encouraged as soon as possible

The sutures are removed on about the tenth day and the patient is discharged to home or a convalescent hospital about four days later

Precautions against gaining too much weight should be emphasized The patients remain in the same plaster jacket for six or seven months after operation The cast is then removed, anteroposterior and right and left oblique x-ray films are taken, and a new light plaster jacket is applied from over the shoulders to the pelvis If these films show a solid mature fusion mass, the patient may be allowed up If there is any question about the maturity of the fusion mass, the patient is not allowed up for one, two or three months longer While some correction may be lost in the original turnbuckle jacket, most correction is lost by letting the patient up before the fusion mass is mature

There were few significant complications in Cobb's 672 operations but no deaths due to surgery With good cancellous bone from the bone bank, Cobb does most of these operations in one stage Fresh cancellous bone from the patient or donor is probably the best because it revascularizes fastest Cobb is pleased with the results of cancellous bone-bank bone for supplementary bone in scoliosis fusions

The spine fusion operation should be done with the aim of getting a solid spine fusion as though no other bone were available

Breck and Millington prefer a two-stage procedure for spinal fusion for patients considered to be questionable operative risks

Resection of the prominent ribs on the posterior aspect of the thorax, on the convex side of the scoliotic curve, was described by Buchman

Whitman, described the procedure utilizing the resected ribs as bone grafts for the spine fusion Bickel Hinche, and Clagett, performed some of the operations in two stages owing to the general poor condition of the patient and to the duration of the procedure

In addition to the cosmetic effect of the thoracoplasty the resected ribs provide ideal bone graft material for the spine fusion Their normal curve will be found to almost exactly approximate the curve of the area for fusion Moreover they are composed of both compact and cancellous elements which provide both structural strength and osteogenic material

The value of a two-stage procedure has been greatly enhanced by the use of refrigeration as a means of preserving the grafts

The use of staples to span epiphyseal growth centers is advocated by some surgeons Reith, Hopkins and Dunlap describe a combined thoracic and orthopedic surgical team approach to the curve in the thoracic spine

principles of force (1) by applying a bending force in a hinged turnbuckle jacket, (2) by exerting a lateral shifting force

Specific Designation of Area to be Fused —1 *In single primary curves*

(*a*) Before termination of growth Fusion of the primary curve and the transition segments to a horizontally level vertebra above and below

(*b*) Postgrowth The minimum area for fusion includes all of the primary curve

Exceptions Include pelvis in

(1) Poliomyelitis—in moderate and severe lumbar curves requiring hinge jacket correction followed by double transection maximum shift retention of correction

(2) Associated spondylolisthesis

Also include one additional vertebra in the flexible lumbar compensatory area, in the thoraco-lumbar curves of moderate degree

2 In double primary curves

(*a*) Double deforming (pregrowth and postgrowth) Fusion to extend from the upper vertebra in the upper primary curve to the fourth lumbar

(*b*) Single deforming

(1) Before termination of growth Fusion of both primary curves

(2) Postgrowth Fusion of all vertebrae in the clinically deforming curve Also include one vertebra in a flexible clinically undeforming primary lumbar curve

3 Curvatures due to congenital anomalies

(*a*) In single lumbar hemivertebra excision Postoperative wedging jacket Jacket closure of the space and fusion of adjacent vertebral segments

(*b*) In inexcisable single anomaly or clusters of lumbar or thoracic hemivertebrae

(1) Before termination of growth Fusion through anomalies to a normal vertebral body, above and below as early as evidence of progressive deformity is established

(2) Postgrowth Wedging jacket

(*c*) In area of multiple incomplete segmentation of vertebral bodies *Wedging or transection jacket correction* *Selection of fusion area* Routine technic

Von Lackum s transection jacket includes both the thighs and the head It is divided transversely into two parts at the junction point of two equal curves This level is either at or near the lumbosacral junction in the single primary lumbar curves and at the lower end of primary thoracic curves This jacket has neither hinges nor turnbuckles Correction can be accomplished at any time within an hour after the jacket has been applied In the flexible curves the correction is usually effected by a manual shift of one transected portion of the jacket upon the other In the more rigid deformities the hinge jacket is preferable Surcingles or ratchets may be used to increase the degree of correction In flexible single primary curves in the lower thoracic area, corrections have been made by two trans-

completes its excursion of ossification across the iliac crest to its posterior limit, dipping down to make contact with the ilium. About 10 per cent of persons have a short excursion dipping down about one-half or three quarters of the way across the ilium. About 1 per cent have a posterior ossification center. The earliest completion of development has occurred in seven months.

Risser finds two important bone changes, loss of horizontal bone trabeculation and epiphyseal changes in many paralytic scoliotics. It is likely that there is more than one etiological factor in many cases of lateral curvature, that muscle paralysis may have been superimposed upon a curvature already present in a nutritionally deficient child. This vulnerability of the vertebral bone may explain why some scoliotic patients have such a rapid increase in their deformity.

In cases of **fixed pelvic obliquity** and lumbar scoliosis, Irwin advises correction of the pelvic obliquity by means of surgical release of the abduction and flexion contractures below the iliac crests. This is accomplished by a Soutter or an Ober fasciotomy combined with a Yount fasciotomy.

Irwin has three criteria for fusion: (1) a rapidly progressing curve which cannot be controlled by conservative measures providing the patient is a suitable candidate for surgery, (2) pain, (3) fatigue and instability.

To return the pelvis to a level position and to restore the symmetry of the abduction triangles, surgery is followed by fixed skeletal traction plus plaster wedgings.

Irwin's plan of treatment for patients with severe iliolumbar soft tissue contractures is the following. The patient is placed in a double spica with fixed skeletal traction. While the body portion of the cast is being applied, the lumbar segment of the curve is forced to a vertical position as nearly as possible by the application of pressure against the apex of the curve. The thoracic segment of the curve is allowed to increase. As the spica hardens, the lower extremities, pelvis and lumbar segment of the curve are fixed in plaster as a unit.

When the spica has thoroughly hardened, the body portion is cut in a circular manner at the level of the apex of the curve with the exception of a four-inch plaster hinge on the side of the convexity. The upper segment is wedged over, utilizing the plaster hinge as a fulcrum.

Risser finds that x-rays clearly visualize deviations in early incipiency. They also reveal the time and course of iliac apophysis ossification in relation to the termination of deformity. This has added a very helpful diagnostic corollary.

Significant in determining the clinical course in progress are protractor measurements of films taken periodically during the observation period.

Of equal importance in jacket correction therapy preliminary to surgery are protractor measurements of films made of curves taken in the sitting bend-tilt position for estimation of the desirable amounts of correction.

After correction and selection of the exact area to be fused in the combined jacket correction surgical fusion regimen, marker x-rays aid in accurately identifying the exact area selected for fusion.

The Risser Principles of Jacket Correction.—Corrective Forces. Correction in jackets, preliminary to fusion, is carried out with two different

(5) More massive maturity is necessary in scoliosis fusions than in most other cases except, e g, tuberculosis and spondylolisthesis

(6) Loss of correction is due to failure of fusion and inadequate or immature fusion mass, or both

(7) Oblique x-ray films are of great help in visualizing the fusion mass

(8) The greater the curve, the more rigid is the curve, and the more difficult is the correction the older the patient the more danger there is of losing correction

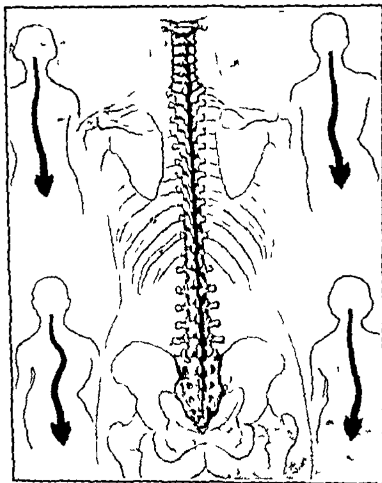


Fig 118 — Various types of scoliosis (Courtesy of S H Camp Company)

(9) Some patients lose little correction even when allowed upright in three months

(10) Most patients should not be allowed up until eight or nine months postoperatively

(11) The long thoraco-lumbar curves which look worse cosmetically are easier to correct but lose correction easily

(12) The use of adequate good cancellous bone-bank bone has simplified Cobb's fusion procedure in scoliosis cases often eliminating three of the four procedures formerly necessary

John Cobb considers two important decisions to be made, viz 1 How many vertebræ to fuse? 2 Should one fuse between parallel lines?

verse cuts in the jacket, leaving a central portion which embraces the central primary curve. This double transection has the advantage of forcing the three curves into alignment simultaneously. This makes it possible to take full advantage of all the correction obtainable in the primary curve and at the same time to correct the reverse curves.

If balance is to be maintained in the surgical treatment of scoliosis, the amount of correction advisable in a primary curve must be determined entirely by the precalculated spontaneous reversibility of the compensatory curves.

Von Lackum found that many of the substandard results in the hinge jacket treatment of scoliosis could be traced to excessive correction in single primary curves. He also found that the failure of compensatory curves to reverse spontaneously in response to jacket correction of a single primary curve was a consistent finding.

Ferguson claims that a curve which shows full correction on the **tilt test** will not cause damaging disalignment after fusion of other curve or curves. The test should be much more widely used, as an aid in determining whether or not the lower half of the spine contains a curve or curves that do not need to be included in a contemplated fusion.

The tilt test is performed by roentgenographic examination in the erect position with the pelvis raised three or four inches, first on one side and then on the other by a sandbag under the buttock if sitting or a lift under the foot if standing.

It is a fundamental principle of scoliosis that, after a deformity has been induced in one or more locations in the spine, the unaffected portions of the spine and the pelvis tend to align themselves in such a way that the body will be in balance, with the head erect over the center of the pelvis; this alignment will be attempted in the easiest possible way. Von Lackum uses the term **"righting reflex"** to express this principle.

Interesting and Important Notes on Scoliosis.—Cobb offers the following words of advice: *Always examine the back during the examination of any patient under sixteen years of age.*

Check all post-polio cases of scoliosis at least every six months for ten years after the acute episode.

When a curve is noted in a patient under age fifteen or sixteen, adequate x-ray films should be taken. These films should be repeated every three months until the patient is fifteen years old.

The indication for operation depends on many factors, and each case must be considered as an individual problem. Cobb fuses less than 5 per cent of his idiopathic cases. He never operates during the heat of summer. The surgical recovery room should be air conditioned.

Cobb listed 12 points of interest as follows:

(1) Spine fusion can maintain correction obtained and prevent increase in the curves.

(2) The chief benefits result from maintenance of correction and stabilization.

(3) Even the frailest patients can be fused without undue risk.

(4) The success of the fusion depends on good surgical technic, large mass of good bone, adequate immobilization, sufficient time for maturity, and good general and local bone metabolism.

SCOLIOSIS WITH PARAPLEGIA

Forty-seven cases of scoliosis associated with paraplegia have now been reported in the literature. The most recent and complete review of the condition was given by McKenzie and Dewar, who emphasized the value of timely laminectomy with division of the dura. They believed that spine fusion was neither desirable at the time of laminectomy nor necessary at a later date.

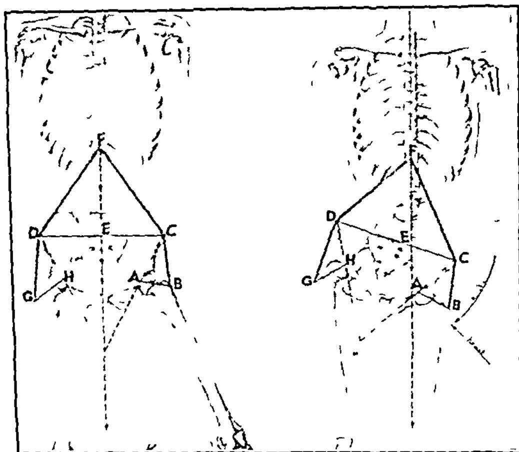


Fig. 120 Fig. 121

Fig. 120. —The majority of cases of true fixed pelvic obliquity are initiated by contractures below the iliac crests. This figure shows an abduction and flexion contracture on one side. The pelvis is the fixed point from which the contracted tissues abduct and flex the thigh. If the extremities were to remain in this position the condition would be localized and no problem of widespread importance would result. This, however, does not follow. Obviously it is impossible for an individual to walk with the extremities in this position. (Irwin, courtesy of J. A. M. A.)

Fig. 121. —When the abducted extremity as shown in Fig. 122 is brought into position for weight bearing the femur becomes the long arm of the lever that forces the pelvis down on the same side. The abductor group BC is rigidly contracted and as the extremity swings through an arc to take a weight bearing position the pelvis and the lower extremities move with it as a unit. In addition to the depression of one side of the pelvis a lateral force or thrust is transmitted through the head and neck of the femur to the acetum displacing the pelvis toward the opposite side. Adaptive shortening of the lateral trunk muscles above the pelvis on the opposite side takes place secondarily to conform to the abnormal position of the pelvis. The pelvis is held in this oblique position by these two contralateral contractures until fixation with skeletal changes takes place. Note the complete loss of symmetry of the abductor and lateral trunk triangles in the presence of the lumbosacral scoliosis. (Irwin, courtesy of J. Bone & Joint Surg.)

Some of Cobbs' words of advice are Asymmetry of the pelvis is important

Pelvic obliquity presents a difficult problem The x-ray is the best indicator of the situation One should use a protractor freely (Cobb's protractor is extremely simple to use and is very helpful) There are factors that modify the prognosis Cervico-thoracic curves offer the poorest outlook Sharpness of angulation is a bad sign

It is a good rule to Make Two A-P Views One for the record One for drawing lines and estimating angles Standing films show the maximum curve Films should be made with and without support

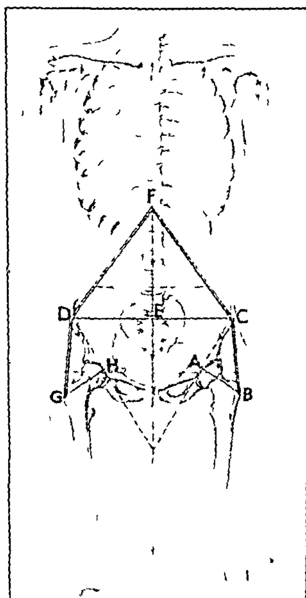


Fig 119 — A graphic illustration of the normal balanced skeleton The pelvis is level The spine is straight There is no abduction or adduction of either lower extremity Note the triangles below the iliac crests These triangles are called the abductor triangles In the absence of a pelvic obliquity these triangles are symmetrical One is the mirror image of the other (Irwin courtesy of J A M A)

In the majority of cases recently reported the paraplegia was found to occur at the period of most rapid growth, between the ages of eleven and nineteen years. Although scoliosis is seen most commonly in girls, the occurrence of paraplegia as a complication is seen most often in males.

In Kerr's case the deformity was due to *von Recklinghausen's disease. Complete recovery from paraplegia was achieved as a result of spine fusion alone.* Previous to this spine fusion as the only operative treatment has been reported once. In that case there was, however, no improvement in the degree of paralysis although the fusion was regarded as sound. There are records of *two cases of paraplegia developing in patients suffering from von Recklinghausen's disease.* In one of these the *laminectomy and division of the dura were performed but no improvement was observed* in the year following operation.

McKenzie and Dewar found that, in idiopathic scoliosis with paraplegia, laminectomy and decompression of the cord will suffice. However, in scoliosis associated with such conditions as neurofibromatosis it is felt that fusion is imperative if the progress of the scoliosis is to be checked and further cord pressure prevented.

If the associated paraplegia is incomplete and of only short duration it is suggested that a preliminary fusion in the concavity of the curve may safely be embarked upon. Should no recovery occur in the paraplegia, decompression of the cord may then be performed with the comforting knowledge that no increase in the degree of curvature is to be anticipated.

Fig 122 Fig 123

Fig 122 — A cellulose acetate jacket made with six layers of stockinette and celluloid acetate on a plaster torso. This is a very efficient support for the more resistant curves. This jacket can be worn with or without crutch attachments. (Irwin courtesy of J Bone & Joint Surg)

Fig 123 — A canvas corset with fairly rigid stays is the most popular support. Its advantages are (1) It is very light in weight (2) it is inexpensive (3) it provides excellent support for weak abdominal muscles. Its disadvantages are the following. It is inefficient unless it is kept tightly laced. The prolonged use of a tightly laced corset will produce an hourglass constriction of the trunk. The canvas corset is insufficient support for a thoracic lumbar curve. It will conform to the flexible compensatory curve in the lumbar region and exert no corrective force whatever on the fixed curve in the thoracic region.

Simple crutches attached to the canvas corset are effective in supporting a weak upper back. An axillary crutch with a wide bearing surface can be attached to the corset on the side of the concavity of the curve and the spine can be pulled to an upright position by a pad and straps. This provides a three point corrective support which is useful for lumbothoracic curves. A simple crutch must be used under the opposite axilla to prevent the corset from rotating. (Irwin courtesy of J Bone & Joint Surg

Fig 124 — Risser's frame for scoliosis

small rug must be used on a highly polished floor at the top or bottom of a flight of stairs, it should be fixed in position with a few tacks. Bathroom hazards are numerous. Porcelain and tile tubs are slippery, a rubber mat at the bottom of the tub is an inexpensive safeguard. This mat should be sufficiently rough so that even soapy feet will not skid. There should be several properly placed non-porcelain handles that can be grasped in getting into or out of the bathtub. This is especially important for elderly people. Suspended webbing straps afford grasping objects.

Automobile Injuries.—Some of the most serious automobile injuries involve the back and pelvis. Automobile injuries peculiar to the back are chiefly sprains sustained in getting in and out of the car, collisions, turnovers and going into ditches.

Direct Injuries to the Back.—Direct injuries as from blows may involve the soft tissues or the bones. Indirect injuries to the back from twists produce strains, sprains or ruptures of tissues. Concussion of the back means a shaking up. It involves the bones and soft tissues, especially the spinal cord and nerves. Concussion is from a blast injury, may occur on land, in the sea and in the air. Postural strain may occur whether the person is standing, sitting or lying.

LOW-BACK STRAIN DUE TO INDUSTRIAL ACCIDENTS

The difficult element in the consideration of cases of back injury lies in the estimation of the actual value of the symptoms compared with the evidence of the injury as obtained by the examination. Cases of strain may be considered from two points of view: first, in relation to the character of the violence causing the injury, and second, in relation to the condition existing in the spine at the time of the injury. In general the injury occurs either as a local wrench, almost always in the lumbosacral area, or as a general strain involving a larger area, and in each the mechanical etiology often has a direct bearing on the diagnosis and may also be of aid in forming an estimate as to the degree of resulting disability.

Causes of Industrial Disabilities.—The chief causes of industrial disabilities of the back are sprains, strains, fractures and dislocations. The most important injury is fracture, which may be complicated by dislocation. Displacement of the involved bone and its fragments, tearing of ligamentous support, hemorrhage into the tissues and fascial spaces, and the injuries to blood vessels, nerves, and lymphatics are considerable. The symptoms are pain and disability.

Every occupation involves the use, overuse or abuse of certain tissues. Therefore each occupation has its own peculiar and particular type of trouble. Railroad workers and firemen are subject to fractures and dislocations.

Herndon made a study of 941 consecutive cases of back injuries in industrial employees. The most frequent site was the lumbosacral region, where two thirds of the lesions were located. In nearly 11 per cent the condition seemed to be sufficiently localized in the region of the sacro-iliac joint to warrant the term sacro-iliac sprain. The next most frequent site was the middle and upper lumbar regions.

CHAPTER 21

TRAUMATIC AND INDUSTRIAL CAUSES OF BACK DISORDERS

THE INJURED BACK

THE chief traumatic causes of backache are strain sprain, concussion, contusion, rupture of soft tissues, compression, crushing, displacements, hemorrhage and avulsion Fractures, dislocations and subluxations are discussed elsewhere in this book

Direct injuries to the back may affect the soft tissues and the vertebræ Concussion of the back may likewise affect the vertebra, the spinal cord *and its peripheral nerves, or other soft tissues collectively or individually*

The chief types of injuries are direct blows, twists and leverage strains In some cases the cause of the injury is a force that is applied quickly and is immediately dissipated In other cases the force continues to operate for an indefinite period

Injuries to the back may be acute, subacute or chronic They may be mild or severe, single or multiple, evanescent or persistent, short lived or prolonged Trauma may be the sole factor in the causation of a lesion or it may occur synchronously with a local or focal infection in the back The injury may involve the body of the vertebra and any or all of its components including the intervertebral disks It may damage the vertebra or disk severely without displacing them or it may not damage them at all but displace them a considerable distance The injury may spare the bone and joint structures but seriously injure muscles, ligaments, fasciæ nerves or blood vessels

The chief injuries to the back are occupational, athletic and military Both acute and chronic conditions may be caused by trauma, which may twist or crush the tissues of the back The combination of trauma and infection may produce a difficult situation

About one-half of the accidents occurring in homes are falls, and most of the victims are elderly persons Misplaced or wrinkled carpets and rugs are common hazards Eyes may not be keen enough to see objects over which stumbling may occur and muscles may fail to respond quickly enough to right the body in time to prevent disaster Highly polished floors and poorly illuminated rooms, corridors and stairways are also responsible for many back injuries A fracture may be sustained by falling out of bed

There is danger of injuring the back incident to standing on chairs or boxes The household ladder is prone to tip, slide or fold up Many a crash has occurred because the housewife insisted on carrying an armload of boxes up or down a stairway with the pile so high that the steps could not be seen Stairs, rails and floor covers are also sources of danger If a

are subject to exactly the same ills. They can be strained so that the muscles and ligaments surrounding them are overstretched and become painful. They can be sprained, their ligaments being then overstretched or ruptured. Traumatic synovitis with its usual sequelæ, effusion and adhesion formation may then follow. Fractures of the intervertebral joints may cause synovitis and impaired function just as in the elbow.

Spinal ligaments which connect the various vertebræ are strong. When deprived of the protection of healthy muscles they gradually stretch and lead to relaxed, unstable joints. This relaxation in turn leads to bad posture and chronic strain. Intervertebral disks, with their strong annuli fibrosi and nuclei pulposi, not only act as buffers between the vertebræ and as strong connecting links, but are subject to injury and disease. The muscles of the vertebræ are subject to strain, fatigue, rupture or inflammation. In addition to all this, the close relationship of the nerves to the bone and joint structure of the vertebræ, makes them extremely liable as they leave the spinal canal, to irritation or to pressure. Thus one should consider a vertebra as a complicated machine, any one of whose parts by breaking down, may throw the whole mechanism out of coordination.

The employer and the insurance company are willing to face the problem of backache squarely, and allow proper treatment of such cases. Unfortunately mild cases are not presented immediately after injury when diagnosis is easiest and treatment most satisfactory. Delay still results from the unwillingness of the workman to quit for what he laughingly calls a "crick" in his back and from the tendency of the factory foreman to consider minor back injuries so unimportant as to need only the attention of the factory first aid station. Both of these attitudes must be overcome by education. All back injuries, except those involving fracture, dislocation or pre-existing bone change, can be cured promptly and easily by early, efficient treatment.

All injuries of the back produce definite lesions which can be recognized by their symptoms and signs. One should visualize and treat a sprain of the back exactly as he would a sprain of the ankle. When such a sprain occurs there is tearing of the ligaments of one or more of the joints, producing hemorrhage in the periarticular tissues and effusion into the joint.

When a man lifts a heavy weight while his body is in a disadvantageous position, there may be a sudden snap in his lumbar region accompanied by knife-like pain. He loses all strength in his back at once and is unable to straighten up. Gradually he resumes the erect position and the pain subsides. If the damage is slight he may continue work; if great, he has to be taken home or to a hospital.

Industrial and Occupational Aspects of Back Disorders. — These include the most important considerations of all back disturbances. They are becoming a focal point in industrial medicine and surgery. The economic aspects are paramount because the monetary loss is staggering. The roentgen-ray examination furnishes many surprises. The medico-legal aspect of the roentgenologist's report is important. The treatment must be adequate and promptly applied.

The predisposing causes involve the mechanical apparatus, the installations, the *surrounding* objects and the potential victim. The direct or

Patients with low-back pain due to industrial accidents do not improve rapidly or as completely as those treated in private practice Bohart found that nearly every patient who has had any kind of an accident, and who discovers any sort of pain in the back, almost invariably attributes backache to the accident He can usually trace the origin of the trouble to some strain or blow Roentgenologic study should be made of the vertebral column of every employee prior to assuming his duties in industries in which injury to the spine is common

The history is important The mechanical conditions under which the injury was sustained is often of great assistance in visualizing the damage done, the position the patient was in at the time of the accident, his description of the pain and its localization and distribution are vital to the proper disposition of his case

Accuracy of diagnosis is essential not only that proper treatment may be carried out, but that anatomical repair may be helped restoration to function hastened and the period of disability shortened Precision in diagnosis even under the most favorable conditions is not often obtainable since many cases show no demonstrable bony lesions under roentgen examination

A careful history a painstaking examination with a proper understanding of symptomatology, and finally good roentgenograms taken in the antero posterior and lateral planes, interpreted with an understanding of the possibility of abnormalities involving the region, should enable one to make an accurate diagnosis, give a prognosis and lead to proper and successful treatment

Brackett states that vertebrae once the seat of injury can hardly be expected to endure repeated stress with impunity The only definite way of correcting a loose or defective articulation is to fix it firmly by a bony fusion The lumbosacral region is frequently the site of abnormalities and of congenital deformities which make it a potentially weak point and render it less resistant to injury In a normal spine, injury of the lumbosacral articulation recovers as a rule with adequate fixation and physical therapy In a spine having an insufficient lumbosacral articulation recovery rarely takes place so that long continued and even permanent disability frequently results Where a definite weakness of the lumbosacral articulation can be demonstrated in patients with a disability period lasting over several months elimination of the incompetent joint by ankylosing the 5th lumbar vertebra to the sacrum offers the greatest expectation of relief

The most common causes of mistakes in the handling of injured backs fall into three main groups according to Kidner The first of these includes errors which result from ignorance of the true anatomy physiology and pathological changes in the spine The second concerns inefficient and inaccurate methods of examination The third is improper treatment based on faulty diagnosis

Although the joints of the spine have a very small range of motion, they are in other respects like the knee or ankle They have articular cartilage ligaments and synovia They are controlled and supported by muscles and being anatomically and physiologically like the knee and ankle they

ordinary force acting on weak tissues. The force is usually applied over a very short period and catches the tissues "off guard."

A sprain is a local condition due to the application of a mechanical force acting upon normal tissues that are placed in or forced into grossly abnormal anatomical relations, causing organic dissolution of such basic structures as ligaments, fasciae and capsules.

The mechanical force producing strain or sprain may be a primary or a recurrent one.

The term, strain, indicates the application of a force greater than that which the supporting elements are normally able to withstand. The difference between a strain and a sprain is one of degree. A sprain results where the acting force is continued for a longer period than in strain. The differentiation is important from the standpoint of treatment and prognosis. Intra-articular structures, as well as muscles, tendons, nerves or blood vessels in proximity to the vertebral joints, may be injured directly or indirectly.

A strain is a minor injury which is normally followed by rapid repair if it were permitted to heal. Chronic strains are usually due to occupational or postural burdens placed on normal or pathological tissues. Following acute strain when the back continues to be painful beyond the ordinary period of repair the condition enters a chronic state. Any force which suddenly or slowly stretches the tissues beyond their normal resisting strength to the extent that a tear occurs, will produce pain and tenderness.

Back strain may occur while lifting unusually heavy objects or while lifting objects that are not unusually heavy but while the potential victim *is in a position of poor mechanical balance. Back strain frequently* is due to attempts to open a window. There are ordinarily two factors: one is the actual injury itself, and the other, the sudden muscular effort put *forth to protect the person from strain. The location of the strain is usually* in the lumbar, lumbosacral or in one of the sacro-iliac regions.

There is a definite reciprocal relation especially when the feet are affected primarily. It may not be easy to determine whether the disturbance primarily affects the back or the foot. In some instances foot symptoms may be secondary to back strain, while in others a backache may be relieved by treatment of the feet. This treatment includes correction of such local static disturbances as metatarsal depression, pronation, ankle valgus and inequality of length of legs.

The term "sprain" is applied to a joint that has been suddenly twisted or wrenched, thereby stretching the ligaments until they become torn or separated from their attachments. A sprain is painful because it is essentially an injury to the nerves of the ligaments. These nerve terminals are the points of origin of reflexes acting on the joint structures and the blood vessels of the muscles.

Sprains of the back may be produced by a twist or a sudden turn such as may occur in stepping onto a street car track or a cobblestone, stepping on or off a curbstone, getting into and out of an automobile, catching a heel and stumbling or falling, jumping with the weight of the body thrown unevenly on one foot and leg, or slipping on the sidewalk. Athletics, and routine occupational activities produce many sprains.

immediate causes concern defective machinery, improper methods of handling it and carelessness on the part of the worker

In all cases of accident, the surgeon should obtain the history so minutely that he can analyze the mechanics of the injury as though he had been very close to the patient when the accident occurred A traumatic surgeon must send his injured man back to work in good physical condition in the shortest possible time He should keep accurate records He should be prompt in completely reporting injuries and must keep copies of every report

Insurance organizations demand shorter hospitalization, a quicker return to duty and earlier adjustments of claims An employer is liable for compensation when an employee dies from pre-existing disease proved to have been aggravated or accelerated by an accidental injury sustained in the course of employment

Many people whose backs are injured in industrial occupations, suffer long periods of disability and incapacity to perform their usual occupations

The types of accident are as follows 'Hit by boom of a derrick,' 'staging fell on him' 'struck by falling timber,' 'caught in a trench cave in,' 'steam pipe fell on him,' etc

Certain areas of the back appear to be more vulnerable to injury than others The most common points of injury are the lumbosacral joint, and the ilio-lumbar and sacro-iliac ligaments There is often immediate disability

The severity of the symptoms depends on the injury and the tissue involved Strains involving the sacro-iliac joint manifest the severest symptoms are resistant to treatment and are prone to cause long periods of disability Injuries involving the attachments of the powerful back and pelvic muscles are next in severity and those involving only the bellies of the back muscles are usually less serious Roentgenograms should be made of every injured back Successful management of these cases demands immediate and firm strapping which should include the entire pelvis It should include the whole area from the trochanters to the costal margins and remain in place for about seven days External heat should be applied As soon as the adhesive is removed, a pelvic support should be worn day and night and physical therapy prescribed A routine of one or two hot baths daily followed by massage should be carried out for about one week

Early return to work is advisable unless it will definitely delay recovery

STRAINS AND SPRAINS OF THE BACK

The subject of sprains and strains of the back is important because of the inherent danger of neglect or overtreatment laying the ground work for future chronic complaints and the psychological hazard Injuries render the back more vulnerable to future injuries and possibly diseases or neoplasms

The terms are often used loosely especially in making reports of injuries incurred during industrial occupations A strain is a local condition due to the application of an unusual mechanical force to normal tissues or an

should repeat his observation of active movements, passive movements, tender spots, reflex tests and tests for sensation

Prognosis.—Factors which determine prognosis in industrial injuries are (1) the injury itself (because some injuries indicate a poorer prognosis than others), (2) the treatment that has been given (3) the time that has elapsed between the injury and the beginning of proper treatment, (4) success of the treatment in respect to mechanics, alignment replacement and reduction, (5) results shown by roentgen-ray films made in at least two projections, studied carefully in front of a well-lighted view-box with additional stronger lights for dark areas, and examined also with a magnifying glass to be sure that no defects have been overlooked, (6) the patient's psychological attitude toward himself, his injury and his employer, (7) economic factors in the patient's home life

The outcome of traumatic lesions of the back depends upon (1) the liability, (2) extent of the injury, (3) time that elapses before treatment is started, (4) the patient's attitude toward his injury Elementary psychology and the desire for financial gain are difficult to evaluate and overcome Disability incurred in private life is much shorter than when industrially acquired There is a striking difference between the degree of pain and the duration of disability when another person or a company is liable for the injury If a painter falls off a ladder while painting his own house and injures his back, he will be back at work several weeks earlier than if his injury had been sustained while working for a corporation When his back is injured in his own uninsured automobile, a man will not make out as "big a case" as when struck by a chauffeur-driven, high-priced car A college or professional football player minimizes his injuries, but when he becomes an insurance broker or a bond salesman he may unconsciously exaggerate them A boy who breaks his fibula while playing "sand-lot" football, makes light of it, but a similar injury, occurring while scuffling *with his father* will be magnified

The financial loss sustained yearly by employers, insurance companies, and employees as the result of industrial injuries is staggering Another serious angle to this situation is the psychological breakdown of a large number of injured persons both in civilian and military pursuits

Treatment.—Treatment of conditions caused by industrial injuries includes prevention active and continued treatment The patient must be restored to his work at the earliest possible moment This should be done even though he may be unable to perform his full duty, even though he may be used in an advisory capacity only and may be able to work for but a reduced number of hours per day

INJURIES TO THE MUSCLES OF THE BACK

Injury to muscle tissue by direct violence is a common occurrence in athletic activities and is followed by a definite clinical picture Muscle ruptures are often produced by indirect violence

The paucity of case reports on muscle ruptures resulting from direct violence is accounted for by Northway who finds that the lesion seldom results *in complete* rupture of a cross-section of the muscle belly and

There are usually sharply circumscribed areas of pain, tenderness and sensitiveness to movement The pathological changes depend upon the severity and persistence of the force and the local mechanical situation The symptoms in addition to pain, may include shock and hemorrhage The physical signs are chiefly limitation of movement The roentgen ray examination may reveal no abnormalities Treatment should be instituted at the earliest possible moment The proverb that "a stitch in time saves nine" applies to injuries to the back

The statement that "a sprain is worse than a break" has been accepted as almost axiomatic but is grossly untrue Sprains are not worse than breaks, but are usually neglected or inadequately treated, that is they are not treated as serious accidents and the victims are dispatched with inadequate treatment and insufficient warning of the possibility of chronicity Severe sprains of the back should be treated by absolute rest and support for a short period until their true status can be determined

CONTUSIONS AND CONCUSSIONS OF THE BACK

Contusion of the back is commonly due to a blow or a fall It causes hemorrhage into the muscle fibers into the fascia and beneath the skin The treatment is rest cold applications and very gentle massage

Bruises of the back of any serious degree of severity are often followed by myositis In these cases a soothing ointment spread on a large, thick gauze compress should be applied before adhesive tape is used These patients should be directed to have immediate and prolonged rest from heavy work

Concussion of the back means violent shaking up of the back without evidence of organic dissolution of any specific tissue It may occur in a train wreck, in a fall or especially during a blast or air raid

Because of the many facets angles and surfaces of approximation, contacts and movements in the vertebrae small discrepancies small irregularities and small incongruities of surfaces may produce severe discomforts and disabilities While patients with slight abnormalities are often entirely free from pain when they are not bearing weight and show no deformity on examination many have disability and pain when they walk, go up and down stairs, or try to carry on their occupations Such patients should always be given benefit of the doubt One should hesitate to report that they are magnifying their complaints

The chief factor which misleads the doctor and the insurance company is a normal or nearly normal appearing roentgenogram Serious mistakes are often made in determining the prognosis following back injuries and in estimating disability due to such lesions In the interpretation of the roentgenogram one must be careful to evaluate both the positive and the negative factors Even when the position and alignment of bones appear to be normal there may be slight discrepancies causing bone and muscle imbalance which will result in pain and disability In such cases the doctor must be particularly on his guard Signs of trouble may be determined by inspection and palpation After a routine examination has been completed and the notations have been entered on the examination slip, the examiner

at first and progress as strength and mobility increase It is well to begin the exercises with the patient in the supine and prone positions and to include flexion, lateral bending, straight leg raising of the legs singly and together, hyperextension of the back and hyperextension of the legs singly and together As the strength of the patient improves, flexion, extension lateral bending, rotation and flexion with rotation are carried out in the standing position The final step is the carrying out of the exercises against resistance or a load Active exercise is to be preferred and can generally be instituted early

Ruptures of Muscles of the Back — The muscles of the back most commonly ruptured are the erector spinæ The mechanisms are direct blows, twists and severe sprains There is usually instant pain, limitation of motion and a definite tender area The physical examination reveals the localized tender region Roentgenograms are usually not made but when they are made frequently reveal no demonstrable changes

The immediate treatment includes applications of cold strapping with adhesive, a tight bandage such as the scultetus binder and later, physical therapy, especially heat massage and special exercises

A true herniation of muscle is characterized by a bulging of the relaxed muscle through a defect in its sheath and the disappearance of this bulge when the muscle contracts

Ruptures of Fasciæ of the Back —Ruptures of the fasciæ of the back follow the same course of production signs and symptoms and require the same treatment as described under injuries to muscles

ATHLETIC INJURIES OF THE BACK

Every athletic sport has its particular type of injury those occurring during sprints, marathons, hurdles, high jumps tennis, golf skiing and mountain climbing Every athlete should be careful of his feet, ankles back and legs before the athletic season begins Lord Dawson found that proficiency in games often exists with deficiency of frame and its function Games, unless correlated with basic physical training can cause serious overstrain Sports and games are the fulfillment of physical training and should rest on it for planned physical exercises increase the strength, control and response of the body Physical training develops certain qualities which are basic to sound physical education, posture poise flexibility and rhythm of movement efficient respiration and physical and mental well-being

Physical education needs the guidance of trained physicians In the future those who aspire to be medical officers of military organizations should be required to include in their training a basic knowledge of physical education

Athletic teams should be under the supervision of competent physicians Coaches should insist that unless a player is in the "pink" of condition he should not engage in strenuous athletics A player who has received a minor injury or is temporarily indisposed should not be allowed to remain in the game

that there is ordinarily little separation of the damaged fibers The injury also with few exceptions responds well to conservative therapy, and surgical intervention is rarely necessary

Injuries to the muscles of the back by direct violence is a common occurrence in such activities as football, rugby, basketball and soccer

Gilcrest listed the sites of the muscle injuries associated with the occupations as follows

Occupation	Muscle
Load carriers, packers	Neck muscles
Lifters pitchers	Biceps brachii, triceps brachii
Horseback riders	Adductors of thigh
Boxers jumpers, dancers runners tennis players	Muscles of calf
Sprinters	Flexors of the hip
Broad jumpers	Rectus abdominis
Stevedores, golfers	Back muscles
Drummers	Extensor pollicis longus
Tennis players	Muscles about the elbow

The mechanism of the injury occurring from direct violence needs no explanation The mechanism caused by indirect violence in general is thought to occur in a contracted muscle when the antagonistic group is suddenly brought into action This evidently occurs through lack of coordination or muscle balance or when a sudden or unexpected movement takes place in response to surprise or for protection The occurrence of such an injury is aided by a state of fatigue in the muscle substance

The presence of a muscle injury should be suspected whenever a direct blow is followed by pain on moving a muscle over the area The pain at first may not be severe and does not necessarily cause a cessation of activity The pain generally becomes worse after a period of inactivity, especially when the muscle is again actively contracted

The signs present will depend on the degree of injury In the majority of cases the area will show swelling on inspection and a palpable swelling associated with tenderness on pressure The area of swelling and tenderness may extend over a considerable portion of the muscle In cases of severe injury, in which the blow has produced a break in the continuity of muscle fibers of considerable extent the break may be seen and felt and increases in size when the muscle is actively contracted The presence of a break in continuity of a muscle from indirect violence should be suspected when during a sudden or forceful muscular act a sharp pain is felt This pain may be accompanied by an audible snap and a stinging sensation like that from a whip The back will become weak and powerless

Graduated exercise should play a prominent part in the rehabilitation of patients with muscle injuries of the back The exercises should be simple

sensitive spot is selected and sprayed using a circular motion for about one minute The tube of ethyl chloride should be held at least 18 inches from the skin By palpation, other painful spots are found and sprayed in a similar manner until all such areas are treated The patient is then instructed to resume regular physical activities but not to be overactive The immediate relief from pain is dramatic In a considerable proportion of cases it is not permanent but may require repeated similar treatment after several hours It may be necessary in the more severe cases to administer a number of applications One must be careful to see that the skin on which the ethyl chloride has been sprayed does not become frost bitten A good signal to the surgeon to stop the spray is the announcement by the patient that the ethyl chloride "stings"

ADHESIVE PLASTER TECHNIC

The basic principles of the indications and technic of application of adhesive plaster should be mastered in order to obtain the maximum benefits from this valuable procedure The skin should be shaved cleansed and dried before adhesive plaster is applied No water should be used Adhesive plaster will not adhere to a powdered surface Ether or carbon tetrachloride removes grease or oils dries the surface of the skin and enhances the sticking property of adhesive plaster Compound tincture of benzoin when applied to the skin before strapping, forms a sticky, protective layer to which the adhesive plaster can adhere This largely prevents or minimizes skin irritation and facilitates removal of the adhesive plaster It is especially useful when strappings are to be left in place for some length of time, particularly in persons of blonde complexions or thin skins

When removing an adhesive strapping, never jerk or yank the adhesive off the skin, but push the skin away from the plaster In the removal of adhesive plaster from the back and pelvis, it is advisable to remove it from below upwards Before removing large areas of adhesive plaster, saturate the edges with ether or carbon tetrachloride Benzine and gasoline often irritate the skin If mineral oil or cold cream is left in contact with adhesive for fifteen or twenty minutes the plaster can be removed with ease and comfort to the patient Always use a bandage scissors when removing adhesive plaster

The incidence of adhesive dermatitis is extremely low and can be made lower by the intelligent cooperation of physician and patient "Tapophobia" is a symptom possessed by many persons who have had unfortunate experiences with the removal of adhesive plaster in the past, or who have friends who have suffered from adhesive dermatitis

It does not take great strength to tear adhesive plaster It can be torn as easily as tissue paper if the proper technic is employed A folded edge of adhesive plaster cannot be torn by hand Do not store adhesive plaster in warm or damp places Never handle adhesive plaster with rubber gloves They may be irreparably damaged or torn

Football.—The response to treatment of injuries to the back incurred during football differs considerably from that following similar injuries in men and women with poor muscles and persons of middle age. Rough or excessive massage invariably aggravates the symptoms, and over-use causes severe consequences.

Golf.—Golf is a common source of cases of back strain. There is no doubt that pivoting throws an undue strain on the lower portion of the back. Beginners who do not "carry through" suffer from low-back strain involving the erector spinae muscles and the lumbosacral and sacro-iliac ligaments. Gray reported on 3 patients who presented similar symptoms. Their ages ranged from thirty-five to forty-five years. The side involved was the left (all the patients being right-handed). The cause was practice with short-distance clubs, accompanied by a snappy twist of the trunk. Practice is more likely to cause trouble than the actual playing. During practice, one goes through the same movements of the arms, legs, body and feet in rapid succession and throws unusual strain on these structures, whereas in playing, the ball is hit and the player then walks a certain distance, using other muscles. I therefore say that practice may cause much more strain than the playing of golf or any other game.

It would be a boon to many men, especially those who are overweight, if golf courses were only thirteen holes long. Many golfers find that the last four or five holes are hard on their feet, legs and back. The type I refer to are men from 20 to 50 pounds overweight, who have been eating too much meat, fish and other animal proteins, too much starch, sugar, and salt and who drink too much fluid. The last four or five holes give them no pleasure, and they are glad when the eighteenth hole is reached. Many such persons can spare themselves and prevent considerable fatigue and pain by shortening their strides 2 or 3 inches. They should not hurry, and should take every advantage of short rest periods such as are possible at each tee.

The Use of Ethyl Chloride as a Local Anesthetic in the Treatment of Sprains and Strains of the Back

For a number of years athletes who in the course of their activities suffered muscular sprain or strain or the so-called "charley horse" have resorted to a certain form of treatment to get immediate relief. They subjected the injured part to a stream of live steam for a number of minutes followed by a brisk alcohol rub and immediate resumption of their activities, with apparent relief.

Krause substituted an ethyl chloride spray for the live steam. It is imperative that the injured area be carefully examined in order to rule out all organic pathological changes such as tears, ruptured muscles, protruded intervertebral disks, fractures and tissue tears.

The equipment used by Greenfield consists of a tube of ethyl chloride with the spray nozzle and some petrolatum. The part to be treated is first covered with a thin layer of petrolatum to prevent "frost bite." The most

Time is the essence of success in the treatment of strains or sprains. A strapping in time may save a lot of time.

Major disabilities that follow minor injuries can often be prevented by a good adhesive strapping. A strapping is not applied to see how *much* the patient can do but how *little*.

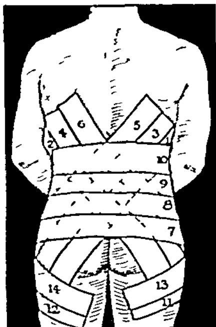


Fig. 126.—Lewin's strapping with reinforcing cross straps. (Courtesy of Johnson & Johnson.)

The greater the gap between torn ends of fibrous tissues, the longer it takes to heal.

When a back is sprained for the first time, it may take six weeks to heal. Subsequent sprains may heal in six days. This accounts for the remarkable recuperative powers of athletes who have repeated strains.

Removal of a strapping should not preclude re-application. A gap in the treatment may jeopardize a good result.

A "notch" or slit in the end of a strip of adhesive plaster eliminates wrinkles and allows for greater purchase area on the skin.

Improved technic in the use of adhesive traction can often diminish the necessity of more radical measures.

In changing post-operative dressings, remember that long, narrow strips of adhesive plaster are often more effective than short, wide ones and cover less skin area. Whenever possible, at each dressing, apply adhesive plaster to fresh areas of skin.

The patient is always impressed by the neatness and uniformity of the adhesive dressing.

A few extra seconds of pressure on its edges may prolong the life of the adhesive dressing. Sharp points of adhesive come off quickly or curl up. One should round edges wherever possible unless it takes too much time. Have proper widths of adhesive on hand. The proper width of adhesive always makes a neater and more efficient strapping.

Special History-taking in Accidental or Industrial Back Cases

The first prerequisite in the study of back injuries is an accurate history.

The history in accident or industrial cases must be unusually complete and specific in regard to the mechanical factors involved.

One inquires concerning the following points:

> Date and hour of accident?
> How accident occurred (the mechanism)?
> Period of unconsciousness?
> Was patient paralyzed?
> Did patient work after accident?
> Is patient getting better or is he getting worse?

Remarks on Adhesive — A strapping is only as good as the "strapper" Simply covering the skin with adhesive plaster does not constitute a therapeutic strapping The object of a therapeutic strapping is to give stability and approximate tissue

Be meticulous to avoid wrinkles and creases

Be careful to protect bony prominences by padding

The vertebral articulations are vulnerable to the same stresses, strains and injuries as are other joints and respond to good immobilization in a manner similar to other joints

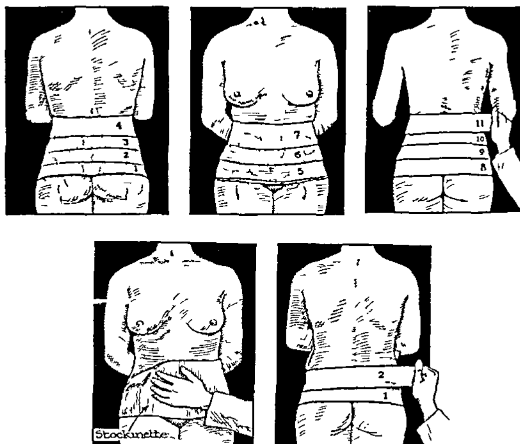


Fig 125 —Lewin's pelvic strapping with adhesive tape (Courtesy of Johnson & Johnson)

A good pelvic strapping will often take the "ache" out of backache, and good traction will often take the "sigh" out of sciatica

One can do "tricks" with elastic adhesive plaster that he cannot do with rigid adhesive Elastic adhesive will turn corners and "stay put," especially on the trunk and the thorax Elastic adhesive and rigid adhesive can often be incorporated in the same strapping to combine the advantages of both

Remember a torn ligament does not show in the roentgen-ray, but may cause weeks of pain and disability

It is not true that "a sprain is worse than a break" It is true that sprains are neglected and breaks are not

TRANSPORTATION OF A PERSON WITH AN INJURED BACK

The basic principles of first aid in back injuries preparatory to transportation are threefold The avoidance of further injury is the prime consideration, all body movement must be reduced to a minimum, apparatus for immobilization of the back must be brought to the patient The patient should be placed in the best position for moving A person with a severe injury to his back should be gently rolled onto his face and abdomen and a roll placed under his midtarsal regions to make his feet comfortable If his toes can protrude downward over the end of the carrying apparatus the roll is not necessary He should remain in this position of neutral recumbency until transported by ambulance to a hospital Injuries to the thoracic and lumbar vertebrae require that the patient be placed on his abdomen, but in injuries to the cervical vertebrae he should be laid on his back with his head and neck extended When a patient is placed on a litter, one's entire attention must be given to supporting and keeping the head and neck in alignment and immobile Immobilization must preclude even the slightest movement of the head and neck This can be accomplished by a cotton collar, gauze bandage, Ace bandage, adhesive, plaster-of-Paris or an improvised brace made of wire, cardboard or felt

Jackknifing' runs the risk of further injury by the projection of bone spicules into blood vessels, spinal cord and nerves Transportation of patients with fracture of spine can "make or break" their chances of recovery Many patients are worse by the time they arrive at the hospital than when they were picked up and some of these changes are due to further injury incurred during transportation

Directions for untrained bystanders, for the laity, for the non-professional person

I Do nothing Do not move, manipulate or turn the injured person

II Wait for adequate help

III Never jackknife a patient in order to move him or to load him into an automobile

Attention should be directed to the avoidance of more damage caused by improper or too vigorous handling of the injured back, and equal consideration for the proper transportation of the patient to the hospital or elsewhere from the scene of the accident

For the acute conditions, the patient should be put to bed on a hard mattress and strapped with adhesive Careful examination and anteroposterior and lateral roentgenograms should be made and the seriousness of the injury estimated If the spine is normal, adequate fixation with strapping brace or plaster cast should be maintained for a period commensurate with the severity of the symptoms Physical therapy is of great value

Speed believes that fractures of the vertebrae should be treated by anatomical reposition, rest reduction of deformity and immobilization The bone lesion is of less importance than the spinal cord injury, therefore one's first thought should be to preserve the cord from further damage

Herndon emphasizes first the diary of previous accidents, pains, aches and attacks of lameness in the back It is imperative that this data should be obtained as early as possible One should obtain a detailed account of the injury in question, that is, whether it was due to direct or indirect violence, a blow, a fall, a lifting strain or twist and if so, what the position of the victim was at the time The mechanical causes have a direct bearing on the diagnosis and are great aids in estimating the resulting disability For instance, there are two general types of sprain The first is the result of severe muscular exertion, the force being exerted by the person himself This form usually results in pure muscular or musculo-ligamentous strain, perhaps with a definite muscular tear or a loosening of the fascial attachments of the large muscles of the back The second form is due to external mechanical violence in which the strain is exerted independently of the patient It occurs most frequently when sudden strains from heavy objects are experienced unexpectedly, as when several men are carrying a heavy load and one or more of them let go their hold without warning thus suddenly shifting the whole load onto one or more of the group This injury is more often ligamentous and may be severe because the muscles do not have time to get into full protective action also the men are usually bent slightly forward in a position of physical disadvantage

Cardinal Considerations in First Aid in Back Injuries

Early discovery of the victim—rapid evaluation of his injuries—immediate appropriate treatment—continuity of treatment

Considerations

I Avoid further injury
II Determine the severity
III Eliminate serious conditions from diagnosis
IV Prevent undue movement
V Relieve pain
VI Support injured back
VII Transport

These considerations are fulfilled by the following measures called treatment

I By avoiding moving injured person until adequate and qualified assistance arrives
II By a very cautious examination without disturbing the injured tissues or causing pain
III Place injured person in a comfortable position
IV Use sedatives if necessary
V Support injured back
VI Stretcher—litter—pillows—blankets—sandbags
VII Get adequate, qualified assistants and vehicles

If the injured person is found lying face downward a board should be placed beside him in the same manner as described above. The head and neck are then steadied between two hands while another person gently rolls him onto the board holding him at the shoulders and hips so that he lies face up. The head and trunk must be turned in unison. The chin should be held up and under no circumstances should the head be tilted forward.

Although there may be no symptoms if a broken back or a broken neck is suspected the injured person should be transported as if his back or neck were broken. When the victim is unconscious he should be handled as though his neck were broken.

If the spinal cord is injured the patient is paralyzed and cannot move his legs because when the cord is crushed there is no muscle power below the level of injury.

When the injured person complains of pain in his back:

1. Keep him lying stretched out flat on his back.
2. Do not move him. Never sit him up especially in an automobile.

If one of the vertebra has been fractured it will slip backward when you sit him up, he will fold like a jackknife where the bone is broken which will crush the spinal cord. Improper handling may cause crushing of the spinal cord and paralyze the person for life. The injury in many cases does not crush the cord, but the man-handling does. This is proven by the sequence of events, *viz.*, an injured person who can move his arms and legs immediately after the accident but suddenly or gradually loses that power. The cause is a progressive lesion in the nature of crushing or hemorrhage. A stretcher should be brought to the patient. He must be kept lying flat until he is well installed in a hospital.

Crushing the spinal cord is like mashing a banana, without breaking the skin. *A fractured vertebra can heal with complete cure.* *A crushed* spinal cord never gets well and the man is paralyzed for life.

When one is confronted with the problem of moving a patient with an injured back the safest course is to keep him in *status quo* until an ambulance or truck is available so that he can be transported lying flat on his back.

Keep him flat until a stretcher litter or blanket-litter is obtained. He should be rolled, not lifted, and while supported in the middle of the back, he is placed in the back of a truck or ambulance.

Don't attempt to lift an injured person by the shoulders neck and legs which will jackknife the spine and crush the spinal cord. If he is lifted in a blanket or sheet or overcoat don't let the middle of the back sag down unless he is on his face, when sagging is beneficial. A seat-cushion can be used as a litter with the injured person's legs and head hanging over the ends.

TREATMENT OF BACK INJURIES

The best treatment of a back sprain is the application of a snug adhesive strapping or a scultetus binder, rest, and the immediate application of cold almost to the point of numbing the tissues. This minimizes swelling and relieves pain. After three or four hours heat is better than cold. Very

When a person sustains an injury to the spine he should not be moved about or rolled over by anyone until a medical person is present. He should be kept in the position in which he was found and warmly covered. Transportation to the place of treatment should be on a flat stretcher with the patient in the prone position. High cervical injuries are an exception. They should be left in a supine position. The strong anterior spinal ligament can be depended upon to hold the vertebrae in place. Schmorl found this ligament ruptured in only 3 out of 2700 autopsies. The neck is steadied by holding the head between two hands.

If the injured person must be moved, the Fracture Committee of the American College of Surgeons proposes the following first aid methods suitable for the physician, the ambulance and the lay public.

A. *A Simple Method to Determine if the Spinal Cord is Injured*.—If a patient complains of pain in his back, he may have a broken back. If he complains of pain in his neck, he may have broken his neck. Never lift an injured person or his head until he has demonstrated whether he can move his legs or fingers. If he cannot move his legs, his back may be broken. If he cannot move his fingers his neck may be broken. In both cases the spinal cord is injured. If you lift his head to give him a drink of water, or if you fold him up to carry him, you may grind the injured spinal cord between parts of the broken vertebra and destroy any useful remnant of the spinal cord which may have escaped injury in the accident. Do not assist or permit the victim to sit up.

B. "*Broken Back*."—When the back is "broken," fold a blanket lengthwise, place it beside the injured person, hold him at shoulder and hips, slowly and gently roll him over onto the blanket so that he rests on his abdomen, placing arms at sides with head turned to one side. If he is on his abdomen do not turn him. One arm may be folded so as to lie beneath his head. By pulling at shoulders and hips the trunk is moved as a unit. Two or four persons may then lift the blanket by grasping it at the level of the shoulders and knees. When the blanket is lifted the victim's back sags slightly downward removing pressure from the spinal cord. The injured person is then placed face downward on a stretcher or similar support. He should then be transported in this position in an ambulance, truck or wagon. At no time permit the injured person to sit up.

C. "*Broken Neck*."—If the injured person with a broken neck must be moved, a board, plank or shutter should be placed lengthwise beside him so that it projects at least 4 inches beyond his head.

The neck is steadied by holding the head between two hands, thus fixing the head and neck. A second person slides the injured person onto the board by pulling at the shoulders and hips so that he rests face upward, arms at sides, head, trunk and extremities on the board. The body, head and neck thus are moved as one piece.

The arms are folded over the chest and pinned or held together. A strap should be placed around the injured person and the board, to prevent him from falling off the board during transportation. The board is then picked up and lifted onto a blanket or stretcher. Either two or four persons form a team to carry the victim. No pillow should be placed under the head or neck. Under no circumstances should the head be tilted forward or sideways.

If the injured person is found lying face downward a board should be placed beside him in the same manner as described above. The head and neck are then steadied between two hands while another person gently rolls him onto the board, holding him at the shoulders and hips so that he lies face up. The head and trunk must be turned in unison. The chin should be held up and under no circumstances should the head be tilted forward.

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gentle massage should be started early, and active motion should be encouraged as soon as the patient's comfort will permit

Serious conditions often follow simple sprains In some cases of deep muscle sprain or contusion, 1 per cent novocaine, or procaine hydrochloride injected into the tender area will give relief from pain during the early acute stages In some instances nerve blocking may be necessary

Osgood offered three good rules in the treatment of sprains, which are especially applicable to the back (1) Be sure the sprain is not a fracture or a sprain-fracture (2) Determine the exact anatomy of the lesion by ascertaining the method of its production and its mechanical necessities (3) Protect the torn ligament or ligaments (usually with adhesive plaster) and allow immediate function

Leriche has shown that following any trauma there is a reflex vaso constriction followed by dilatation of the neighboring vessels Leriche and Fontaine advise the use of periarticular infiltrations of from 10 to 25 cc of 1 per cent novocaine in the treatment of sprains and traumatic arthritis The dose may be repeated daily Leriche contends that in sprains there is no lesion of the ligaments even when edema and marked subcutaneous hemorrhagic suffusion are present, and that the pain is caused by the contracture He affirms that any sprain can be quickly relieved by allaying the pain in the tissues For this purpose he injects procaine hydro chloride deep into the painful area This causes the disappearance of symptoms within a few hours

Brunschwig and Jung found that the sensibility of any joint is primarily a periarticular response due to the large number of nerve endings in the joint capsules and periarticular ligaments In sprains, pain is due primarily to trauma of the periarticular nerve supply Reflex muscular rigidity involving the injured joint area also has its origin in the traumatized nerves of the joint capsule and ligaments Periarticular injections of novocaine have a definite therapeutic value In some instances several injections are necessary Early mobilization of injured vertebral joints permits prompt use of the part unless it causes added pain and limitation of movement

However the injection of a local anesthetic with the idea of relieving pain and thus permitting early activity of the part, may be ill-advised Pain which is caused by an injury is a warning that damage has been done and that further activity will increase the injury A local anesthetic obliterates the warning signal Therefore its use is as much a mistake as the disconnection of a burglar or fire alarm because the sound is annoying

Therapeutic measures are available also in contusions and muscle sprains to hasten absorption of the products of hemorrhage, to eliminate swelling and pain, and to restore function

Early treatment of acute back strains and sprains includes rest on a hard bed with the back extended and the use of heat and massage Early active and passive movements while in the recumbent position are begun when the acute pain has disappeared Activity is gradually resumed, under the protection and support of adhesive strapping, belt or brace Work is resumed only when vigorous setting up exercises can be performed

without causing pain While no time limit can be given as a universal period from three to six weeks is generally required to prevent recurrence

The treatment is essentially rest followed by physical therapy For mild injuries adhesive strapping of the pelvis or traction is usually sufficient For the more severe types, a plaster-of-Paris jacket may be necessary Physical therapy should be started as early as is consistent with the pathological changes present

Sacro-iliac supports and spine braces and corsets may be used in combination with postural exercises muscle training and physical therapy

Just as a badly injured ankle will remain thickened and stiff for months or years, so will a lumbosacral or sacro iliac joint In the ankle the pain remains local *In a lumbosacral joint it may radiate down the sciatic* nerve because the spinal nerve roots are pressed upon as they emerge from the spinal canal The second cause of pain is the fibrosis and loss of elasticity in the muscles and ligaments which follow hemorrhage, tears or repeated strain

The principles of early treatment in severe injuries to the back, are treatment of shock and hemorrhage, protection of injured tissue early resumption of activity

In every industrial case the surgeon must answer the following questions (1) What did the injury do to the body? (2) What did it do to the mind?

Immobilization more than any other one factor reduces the number of local and general complications Uninjured parts must be used and injured parts rested Lowman's polo belt is very helpful

Treatment of Injuries to the Vertebral Joints

The local treatment of injuries to vertebral joints includes support massage radiant heat inductotherm hydrotherapy and hot paraffin applications The proper immediate treatment is the use of a compress kept cold by frequent changes or when muscle spasm is so strong that its alleviation is imperative a local anesthetic can be given

Injuries of even moderate severity cause damage to blood vessels which is followed by hemorrhage into the surrounding tissues Heat causes a dilatation of the peripheral vessels hyperemia of the skin dilatation of the deep vessels and an increase in the hemorrhage When the hemorrhage occurs within strong fascia it increases the ischemia

Functional Disorders of the Back Related to Trauma —This group includes traumatic neurosis exaggeration malingering and hysteria These cases require the combined efforts of experienced neuropsychiatrists and orthopedic surgeons

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The general principles enumerated in the section on traumatic and industrial lesions should be reviewed at this time especially regarding the handling, position and transportation of a person with an injured back or neck

In addition to the natural protection of sponge rubber (dunlopillo) cushions crepe rubber soles and heels the most important factor is the degree of excursion that the pelvis, back and neck are subjected to For example if the body is thrown up violently and bounces down on any object the degree of concussion is considerable It is analogous to the familiar sight of the carpenter tightening the loose head of his hammer by forcibly thrusting the end of the handle against a solid object (The pelvis would be the handle and the spine the head of the hammer)

In addition to wearing a tight pelvic and lumbar belt the excursion of the pelvis and back should be limited by tight restraining straps to prevent bouncing and jostling

Back problems occurring in the military services are often quite different from those found in civilian life The resulting deformities disabilities and death from modern war wounds has been greatly reduced by means of mobile surgical operating rooms, mobile roentgen apparatus and anesthesia units Although the surgery may have to be done under unusual circumstances of haste and sometimes with inadequate equipment and assistance it should never jeopardize the soldier's chances of delayed reconstruction surgery

WAR INJURIES OF THE BACK*

In war injuries of the spine there might be complete severance or spinal concussion

The effect on the conductivity of the spinal cord might be transient except in cases of severance Hemorrhage into the substance of the cord might produce progressive interruption due at first to continued effusion of blood and later to the reaction to its presence A partial lesion might be recognized by persistence below its site of sensibility motor power or reflex activity It indicates that the violence which reached the cord was slight and useful recovery might be hoped for but it might take a year or more These partial lesions may be the only ones worthy of operative or manipulative treatment

In an incomplete lesion the presence of metallic or bony fragments may cause persistent pressure on the spinal cord and should be removed One reason for removing metallic fragments irrespective of position is the prevention of infection When entrance wounds are suppurating freely they should be rendered as clean as possible by a superficial drainage operation before removing the foreign body In neglected penetrating wounds of the central nervous system meningitis is common

* I was chief of the orthopedic divisions of the base hospitals at Camp Grant and Camp Taylor In England while attached to The Royal Army Medical Corps I served at the Third Western General Hospital in Newport Monmouthshire Wales In France I served at Chaumont Chateauroux LeMans Angers Savenay and Paris I also served in the French Military Hospitals World War II Vac Hosp H C O Chief Mayo General Hosp Galesburg Chief Gardiner General

CHAPTER 22

BACK DISORDERS IN THE MILITARY SERVICES

"A wounded soldier is a disabled athlete,
not a sick man."—(De Tarnowsky)

Back disorders are very important in the non-combatant as well as in the combatant forces. From my experience in World Wars I and II, I deduce

1. The causes
2. The mechanics involved
3. The types of injuries
4. The prophylactic measures
5. The appropriate treatment

In my discussion of the military services I have included the situation in nearly every branch of service.

There is the daily run of routine injuries common to all branches of service. There are injuries peculiar to each branch of service because of unique conditions and situations during basic training in simulated battle conditions and in battle action. The treatment depends upon the facilities, the proximity to the spot where the person was injured, the personnel and the equipment.

Every branch of the many military services, every special duty to which service men are assigned and every component part of the back and neck must be considered in a discussion of the numerous mechanical causes, the varied injuries, and their prophylaxis, prevention and immediate treatment.

The tremendous weight, the terrific speed and the colossal destructive capacity of motorized equipment has brought the military surgeon face to face with many serious problems.

The chief disorders are sprains, strains, concussions, contusions, muscle ruptures, fractures, dislocations and lesions of the intervertebral disks. The prevention of these injuries involves the service men, their equipment, their special assignments, land and water highways and the numerous means of transportation on land, on the sea, in the air and in the sea.

Prophylactic measures include special clothing and equipment, cushions, pads, restraining straps and belts and supports. Rough roads, rough terrains and rough seas cannot be avoided.

Blast injuries both on land and in and on the sea, cannot be avoided.

The treatment is divided into immediate and delayed with the preponderance of importance on the former. The immediate treatment of shock and hemorrhage is imperative.

Reports from the battlefields of Korea indicate that infection was a less serious problem than in the World Wars I and II. Most army surgeons feel that much credit for this must go to chemotherapy.

The lacerating, destructive type of wound is the one most frequently encountered in modern warfare. *During the Korean war however* newer knowledge has revolutionized certain phases of the care of these potentially infected wounds. Careful deliberate *débridement* is still the outstanding factor regardless of what other measures are used. The administration of plasma, the use of chemotherapy *and rapid transportation* are exceedingly important.

Ogilvie divides the progress of wound infection into two stages: contamination and infection. In the first stage bacteria (carried in by the causative agent) lie on the surface of the wound, in bits of dirt, mud, grease, clothing, or metal fragments, or in the blood clot. In this stage bacteria can be removed by thorough mechanical cleansing. During the second stage the bacteria, taking advantage of the supply of culture medium available in the dead matter, blood clot, lymph and damaged muscle, multiply and begin to invade the host. The stage of contamination lasts about twelve hours. When organisms are few, the available culture medium scanty, and the surrounding tissues healthy, the state of the patient's skin and clothes and the appearance of the wound will aid in estimating the probable degree of infection.

Treatment of war wounds may be divided into two categories, (*a*) wounds seen early and (*b*) wounds seen late.

Early Treatment.—*The lesson learned from the treatment of soldiers* proved that excision of contaminated wounds at the earliest opportunity after careful cleansing with soap and water was the most valuable prophylactic measure.

Chemotherapy.—*Local application directly into a wound of antibiotics* has done much to prevent severe infections. The golden period from time of injury to time of treatment was considered as six hours in World War I. This period can now be prolonged to perhaps twenty-four or forty-eight hours provided chemoprophylaxis has been instituted early.

The War Wounds Committee of the Medical Research Council and the Committee of London Sector Pathologists have published a review of gas gangrene based on the experience of the former great war and on recent experiences in Spain, France and elsewhere. For prophylaxis they recommend excision of contaminated war wounds at the earliest opportunity.

In early cases in which adequate cleansing and *débridement* can be carried out and chemotherapy applied, primary closure of the wound with widely placed interrupted sutures can be attempted. The number of wounds which heal by primary union, even though grossly contaminated, is surprising.

If there is the least suspicion of burrowing infection, the wound should be left wide open and dressed loosely with Vaseline gauze or gauze soaked in azochloramide. The dressing must be changed frequently.

Delayed Closure.—Delayed closure is recommended in wounds that are more than twelve hours old. In the presence of obvious infection they are thoroughly opened and irrigated with Dakin's solution.

If the patient survives an emergency operation, he may live a long time during which he may have discomfort, deformity and disability because of an incomplete or incorrect emergency operation.

Transportation is a great factor in reducing the incidence of infection. The ambulance plane has made it possible to provide for the wounded, the highly developed surgical facilities of civilian hospitals. Transportation of wounded is accomplished by air-transport without undue difficulty. Those with marked secondary anemia were susceptible to air-sickness which is best relieved by the administration of oxygen, Vitamin B_1 and dramamine.

TRENDS IN MODERN WARFARE AND THEIR EFFECTS ON INJURIES OF THE BACK

Coller and Farris have termed the battlefields "a great laboratory for the study of trauma." The indiscriminate mass attacks directed against densely populated cities coupled with the increased effectiveness of air forces have directed attention to new problems in the present type of warfare. In addition the mechanization of war with its increased mobility presents new problems in the collection and transportation of wounded. The increasing range of artillery fire combined with mobility of the front and the ubiquity of the airplane tend to decrease in type and amount the surgery permissible at the front.

TREATMENT OF WAR WOUNDS TO SOFT TISSUES OF THE BACK

Crushing injuries, stab wounds, gunshot wounds, and perforating wounds are common in the back. They may be due to the impact of a heavy falling object, or being caught in machinery or an automobile door. Wounds of soft tissues of the back may be produced by physical or chemical trauma. The prognosis depends upon the extent and depth of the wound and the presence or absence of infection. In simple wounds primary suture may be successful.

In all cases of extensive wounds of the back roentgenograms should be made in two projections to determine the presence or absence of fracture or dislocation. In large wounds which are actually or potentially contaminated, anti-tetanus serum should be administered. If gas bacillus infection is anticipated, specific serum should be employed. Thorough surgical *debridement* followed by measures to keep the wound clean are more important than the specific type of treatment given.

"Primary suture" means immediate suture of the wound. "Delayed primary suture" means that the wound is left open with sterile packing for from three to five days after *debridement,* and then sutured, layer by layer, as a clean wound. *If the wound is seen early and is thoroughly débrided,* it is permissible to apply penicillin or other drugs in the depths of the wound, and to close the wound in layers by primary suture.

The important natural agencies combating infection are the blood and tissue fluids and the leukocytes. The influence of the fluids is due to their alkalinity, and their antitryptic power. The Welch bacillus grows better in serum from a patient with gas gangrene, a serum which has lost nearly all its alkalinity, than in normal serum.

his side his will to recover is much greater For troops to know that a means is at hand for their care if they are injured increases their morale'

Wound care is more important than chemotherapy There is no substitute for good surgery

I do not wish to minimize the value of chemotherapy We must utilize everything we have found valuable in the past and supplement those measures which are rapidly becoming recognized as helpful

I refer especially to the sulfa drugs penicillin zinc peroxide azochloramide and in particular plasma and speed of transportation

The four horsemen of death in battle casualties are shock hemorrhage infection pain

The most important factors in the treatment of battle casualties are immediate care relief of pain rapid transportation plasma good surgery chemotherapy a pressure dressing and infrequent inspections of the wounds The great value of plasma and rapid transportation has been established beyond question

WOUND HEALING

Mason outlined the following nine factors in wound healing

1 Blood supply Tight sutures and tight dressings render portions of tissue avascular and result in local necrosis

2 Irritants of various sorts including antiseptic drugs and chemicals lower tissue vitality and may even bring healing to a standstill

3 Mechanical or chemically inert irritants *i e*, foreign bodies, may carry organisms into a wound or their presence may interfere with healing Drains interfere with healing If infection is feared the wound may be cleansed and left open to be closed later

4 Hemorrhage and blood clots interfere with healing by preventing the apposition of divided tissue by interfering with local circulation and by furnishing a culture medium for bacterial growth

5 Accurate anatomical restoration of divided structures promotes healing

6 Rest support and protection to the healing tissues are valuable adjuncts Immobilization is needed until the stage of fibroplasia is well under way, this is twelve to fourteen days

7 Non-viable and necrotic tissue delay healing and favor infection Adequate *debridement* cannot be overemphasized

8 Wound contamination depends largely on the tissue soil upon which the bacteria may grow

9 Such general factors as overhydration or dehydration nutritional factors and vitamins are also important in wound healing

BURNS OF THE BACK

Burns of the back may be produced by physical agents chemicals or by traumatic or frictional factors The physical agents are heat and cold the former usually in the form of water oil lead or steel The chemical agents are caustics such as phenol and lye Examples of traumatic or frictional burns are those caused by lamps electric currents cinders and

Foreign Bodies.—Foreign bodies should be searched for, in the depths of every wound. Their localization by means of fluoroscopy or roentgenograms is of great assistance. When a foreign body is located deep in a wound all tissues surrounding that region should be carefully debrided. All grossly dirty wounds should be left open for drainage. Bullets should not be left in the depths of wounds.

Later Treatment.—When injured men come under observation at a late period and organisms of gas gangrene have already reached the living tissues bordering on the wound cavity, or when the wound is passing through a stage of physiological reaction to injury, the optimal time for prophylactic excision has passed and the surgeon must provide adequate drainage. In late cases suspected of gangrenous infection of muscle the wound must be opened wide and the muscles involved, extensively excised.

The best available treatment for an established case of gas gangrene in addition to surgery is a combination of antitoxin and chemotherapy. The antitoxin should be administered intravenously at the earliest possible moment.

With the mechanization of modern warfare the type of injury to the back has become much more severe. Instead of soldiers being kicked by horses or hit by shrapnel their injuries today are of a severe crushing type caused by high explosives or by their being run over by heavy mechanized equipment. Under such ripping and tearing forces the tissues have a wider area of contusion or abrasion, and must be debrided widely.

Tetanus antitoxin and gas bacillus serum should be given routinely to every patient with a severe injury of the back regardless of what surgery or chemotherapy is instituted. In a case with frank pus, zinc peroxide, hydrogen peroxide or azochloramide is used first to clean up the infection and when that is accomplished the surgeon resumes the use of antibiotics. Various combinations of other drugs have been used extensively.

Planes which carried war supplies to the front lines brought back thousands of men to hospitals including both battle casualties and the sick.

The most important factor in saving lives was plasma. Plasma minimized shock and bleeding and without that many men would have died before they reached the installations where they could be given definitive medical care.

Second in importance in saving lives was surgery, which cleaned up the wounds and reduced the incidence of infection. In third place were the antibiotic drugs aiding in minimizing and delaying infections.

According to Brigadier General David N. W. Grant, air surgeon of the Army Air Forces, as many as 600 patients were transported in one day which is three times as many patients as can be carried by a hospital train on any one trip.

"The use of aerial evacuation will be greatly increased in the future," said General Grant. "Aside from medical efficiency brought about by removal from the zones of operation to a surrounding of relative peace and quiet, it is quite obvious that an important psychological element is involved.

"If a wounded man knows he is soon to be in a safe, friendly area, clean and comfortable with all the skill and equipment of modern medicine at

his side his will to recover is much greater For troops to know that a means is at hand for their care if they are injured increases their morale

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scrapings Burns are divided into those of the first, second, and third degree according to the depth of the lesion A burn of the first degree involves only the superficial layer of the skin, and is manifested by hyperemia A burn of the second degree involves all the layers of the skin, while a burn of the third degree involves the deep tissues A burn is practically an open wound Shock, which is common in severe and extensive burns, may be slight, or so severe as to cause death According to Wells, three principles of special importance in the treatment of extensive burns are (1) prevention of dehydration, (2) maintenance of asepsis, (3) promotion of epithelialization

Treatment of War Burns —Most of the burns are due to gun flash bomb flash incendiary bombs or gasoline First aid treatment consists of morphine, warmth and fluid to counteract shock If shock is marked, plasma transfusion is given Secondary shock occurs some hours after the burn and accounts for 80 per cent of the deaths

The most important factor in shock is the loss of plasma from the burned surface The blood may become so concentrated that the hemoglobin rises to 140 per cent The best treatment is to replace the plasma protein Given intravenously plasma raises the osmotic pressure sufficiently to restore the normal balance of fluid between the vascular and interstitial components Whole blood transfusion and intravenous physiological solution of sodium chloride or sterile water are usually contraindicated The amount of plasma necessary must be estimated by frequent blood examinations

Acute toxemia from burns may be due to streptococcus infection It does not appear for several days and can be prevented by primary cleansing before coagulating For extensive burns with toxemia saline baths are valuable In first- or second-degree burns sepsis can be prevented if coagulation treatment is given at once and adequate cleansing and coagulation follow on arrival at a hospital

The Paraffin Wax Open Air Treatment of Burns —Pendleton recommends the paraffin wax open air treatment, which varies from other forms of treatment in the following respects

1 No cleansing or debridement is necessary before application of the wax
2 No gauze or disposable tissue is incorporated in the wax
3 Frequent shower baths form part of the treatment
4 No dressing or covering other than the wax is employed, thus permitting early motion and constant observation
5 One technic serves for burns on all parts of the body
6 The same treatment is used for first aid and for definitive care

Tannic Acid —In 1925 the local treatment of burns was revolutionized by the introduction of tannic acid by Davidson The tannic acid is applied every fifteen minutes for eight hours Seeger uses a solution with a hydrogen-ion concentration of 7 4 which he obtains by adding 3 975 grams of pure anhydrous sodium carbonate and 25 grams of tannic acid to 500 cc of water It produces rapid tanning and the tanned membrane formed is more pliable than that produced by solutions with low hydrogen ion concentrations If the wound was soiled at the time the burn occurred, anti tetanus serum should be given

In a simple burn, unguentine ointment amertan, picric acid ointment, paraffin, butesin picrate, or equal parts of olive or linseed oil and lime water may be employed. Open-air treatment which protects the skin may be given by exposing the wound to a breeze from an electric fan.

Burns may be treated with a 1 per cent aqueous solution of gentian violet applied by means of a swab or a spray or in a jelly. The application is repeated every two hours for the first twenty four. In suitable cases, the "closed method" is effective. Under general anesthesia the burned area is carefully cleansed with soap and water, using rigid surgical technic. The area is next covered with heavily impregnated "Vaseline" gauze which in turn is covered with a sponge, to supply even, gentle pressure, the whole area is then tightly bandaged.

Burns are clinically and bacteriologically sterile during the first few hours, but become infected as soon as the skin becomes necrotic.

Debridement is as important in the treatment of burns as in the treatment of any other wound. Chemotherapy can be instituted in a manner similar to that used in the treatment of potentially infected wounds.

TETANUS IN MILITARY PRACTICE

The administration of tetanus antitoxin for the passive protection of wounded soldiers reduced the incidence of tetanus during the first World War from 9 per 1000 in 1914 to less than 1 per 1000 in 1918. This reduced incidence was accompanied by a lengthened incubation period of from 11 8 to forty-eight days and a lower case fatality rate of 22 6 per cent in the inoculated as compared with 53 3 per cent among the uninoculated.

Powder and bullet wounds, shrapnel, crushing wounds and other injuries are portals of entry for tetanus spores, especially if the wounded soldier lies on the field for some time after injury. Any wound contaminated by soil, manure or debris is a fertile source of infection by tetanus.

Tetanus Toxoid.—Tetanus toxoid is compulsory for everyone in all branches of the military services of the United States of America, the British Army and the Royal Air Force. Two doses of 1 cc of tetanus toxoid are given with a six weeks' interval between. The reaction is slight and the resulting immunity is sufficient to protect the individual for at least two years after inoculation.

An established case of tetanus should be treated with massive doses of from 100 000 to 150 000 units given intravenously and intramuscularly and perhaps also intracisternally or intraspinally, as well as subcutaneously around the wound. The best treatment however is prevention which is accomplished by specific prophylaxis plus early excision of the wound. A combination of chemotherapy and specific antitoxins is most effective in holding invading organisms in check, thereby assisting the natural body defenses in combating the infection. Tolserol given intravenously may be very helpful.

GAS GANGRENE

Gas gangrene is a spreading lesion produced by gas forming anaerobic bacteria in extensively traumatized tissues. It is characterized by a gaseous

infiltration, edema of the part and a change in the color and contractility of the muscles involved It usually follows crushing injuries of the tissues especially of the skin and muscles, and the accompanying contact with clothing or soil contaminated by animal excreta

In open crushing wounds lacerations, injuries caused by explosives and compound fractures which have been contaminated by earth or cloth, especially wool the danger of anaerobic infection is considerable, if there is injury to the local blood supply A wound contaminated by garden soil is a potential site for gas gangrene

Gas bacillus infection may develop in any wound While seen most commonly in military and industrial practice it may follow athletic and automobile injuries The chief organisms of the gas-gangrene group of anaerobes include the Bacillus welchii and the Vibrion septique Vincent found Vibrion septique in about 10 per cent of the cases Streptococci and staphylococci may be secondary invaders

Symptoms and Signs —The signs of gas-bacillus infection are fever, increased pulse rate, pain, discoloration, tenderness, subcutaneous swelling, muscle swelling and crepitus The physical findings are swelling, tenderness crepitation a peculiar odor and an inflammable gas The roentgen ray reveals shadows like bubbles in or between the muscles and in the skin

The first symptom is an increase in the pulse rate which may or may not be accompanied by fever Crepitation, a very important sign, is due to the presence of gas in the tissue A peculiar odor described as a "mousy smell" emanates from the open wound The leukocyte count is increased Restlessness and uneasiness are followed by prostration and toxemia

Tenopyr called attention to early suggestive symptoms (1) pain disproportionate to the amount of injury, (2) the mental acuteness of the patient Locally, there is disproportionate swelling with pallor of the surrounding skin The edges of the wound have a dirty cream color, and the bandages are stained with a red serum There is no pus Bubbles and gas can be milked out of the wound, and crepitation can be felt under the skin After twenty-four hours the area is covered with a dirty, greenish gray membrane a characteristic odor is noted, and there is usually a thin discharge

Roentgen ray Findings —G G Davis was the first to recognize gas bubbles in the roentgenogram in early cases of gas gangrene Olin demonstrated the presence of free gas in the tissues in the first 24 hours, by means of roentgen-ray A small black spot, blotchy in outline, is the first evidence, and if carefully observed, can be followed along the course of a muscle As the infection travels along the muscle fibers and rarely transversely, longitudinal shadows are the rule To prevent confusion of shadows, the limb should be free from splints, dressings, and moisture The prognosis depends upon the severity of the infection and the elapsed time between the injury and the institution of prophylactic measures

Treatment —Treatment includes prophylaxis, surgery, oxygen injection, serotherapy, and roentgenotherapy Surgery provides drainage, *debridement,* including the involved muscle masses, sterilization by irrigations or maggots, and prophylactic incisions in advance of the infection Prophylactic treatment includes the intramuscular injection of from 30 to 60 cc

of polyvalent anti gas-gangrene serum combined with 1500 units of anti-tetanus serum

Debridement includes the removal of all foreign material and devitalized tissue until the area of healthy muscle is reached, as proved by bleeding contractibility on pinching, and color After *debridement* and incision, the wound should be left open for drainage and exposure to the air Various substances have been used for irrigation including hydrogen peroxide potassium permanganate, quinine sulfate, formalin, and chloramine Larson and Pulford recommend flushing the wound with chloramine solution by the Carrel technic every three hours and its coverage with this solution for one-hour periods three or four times a day Some workers favor continuous irrigation with Dakin s solution or daily irrigation with potassium permanganate All wounds should be packed lightly with wet gauze

The best available treatment in addition to surgery, for the established disease is a combination of antitoxin and chemotherapy The antitoxin should be administered intravenously at the earliest possible moment Supportive measures should be instituted to combat the infection In some cases such general measures as blood transfusion are necessary because of hemorrhage or a blood-destroying toxin

CHAPTER 23

INTERNAL DERANGEMENTS OF THE BACK

CONDITIONS included in this classification are

Intraspondylar	Vertebræ Disks	Intraneural	Neuritis Tumors
Extraspondylar	Muscles Ligaments	Extraneural	Radiculitis Disk Syndrome

VERTEBRAL INSUFFICIENCY

The term, vertebral insufficiency, introduced by Camitz, describes an inefficient, inadequate, weak, lame back The syndrome is due to muscular and ligamentous weakness which permits settling of the bony structures The symptoms are pain and limited movements, due in part to poor function of the intervertebral joints and possibly of the disks The patient complains of fatigue of the back He describes the condition as a "settling' of his back a sort of dovetailing of the tissues or accordionization " He states that very soon after fatigue appears, he has a dull pain in his back, which is aggravated by standing and only partially relieved by rest The patient goes through life with alternating periods of comfort and discomfort The condition is a frequent cause of psychoneurosis which is insidious in its onset often subconscious and innocent

THE TELESCOPIC TORSO

THE 'ACCORDION TORSO

The terms "telescopic torso ' and the "accordion torso ' were coined to illustrate what occurs to a human trunk during the course of a day s experience They express the shortening and partial collapse of the torso occurring under certain conditions to some persons Normally, the physiology of the torso proves that there are daily and nightly variations in its length due to diurnal and nocturnal variations in the length of the spine There is definite lengthening of the spine during recumbency and definite shortening during standing and sitting These variations are chiefly due to changes in the intervertebral disks and to the presence or absence of the superincumbent weight of part of the body during the standing period

Patients with Paget s disease, scoliosis osteoporosis or tuberculosis may show an appreciable shortening during standing periods

Elliot and Nadler reported a case of osteomalacia in a wrestler who was several inches shorter at the end of the day than he was at the beginning

THE INTERVERTEBRAL JOINTS—VERTEBRAL ARTICULAR FACETS—APOPHYSEAL JOINTS

The Facet Syndrome.—Ghormley reported a case of backache with symptomatic sciatica, which was due to pressure on the 5th lumbar nerve root by a diminished intervertebral foramen. Removal of a portion of the facets which enlarged the foramen, was followed by immediate relief from pain. The operative procedure consisted in exposing the transverse process of the 5th lumbar vertebra and the facet between that vertebra and the sacrum. The facets were found enlarged with an overproduction of bone. Exposure of the 5th lumbar nerve root disclosed definite diminution in size of the foramen of exit.

Ayers and Putti emphasized the clinical and anatomical importance of the lumbosacral joint and its facets as factors in producing low-back pain. According to Ghormley and Kirklin, the facets or intervertebral articulations make up from a fourth to a third of the margin of the intervertebral foramina. Each articulation is composed of two articulating surfaces covered with hyaline cartilage, the margins being enclosed by a synovial lining. They must be regarded as true joints and as having a perceptible amount of motion.

According to Badgley, the articular facets are true joints provided with a complete capsule, which is lined with a definite synovial tissue. Closely associated with the mesial aspect of the capsule are the ligamenta flava. The outer portions of the ligamenta flava are inseparably attached to the loose articular capsules, preventing by their tension, the occurrence of folds. They encroach on the sides of the capsules toward the canal and take the place of muscle in preventing the capsule from being nipped between the articular surfaces during movement. The ligamenta flava are also important because they restore the articular surfaces to their normal position with regard to one another, after movements of the spinal column.

Goldthwait recognized two important variations from the normal skeletal type which are likely to produce backache: (1) the tall slender visceroptotic type with long narrow flexible spine and the flat type of lumbosacral facets, (2) the short thick heavy type in which the diarthrodial facets are large and crescentic, limiting the motion of the vertebræ, particularly in flexion. Goldthwait pointed out that if the facets are asymmetrical normal movements are disturbed.

Brailsford in a review of 3000 roentgenographic studies of the lumbosacral spine, found that 57 per cent of the lumbosacral facets pointed backward, 12 per cent pointed inward, and 31 per cent were mixed or asymmetrical.

In an anatomical study of the vertebral apophyses, Putti pointed out that while the articular portion of the facets quite generally has a definite shape often the facets are flat and sometimes asymmetrical. He found that *inclination of* the articular surfaces increases in the lumbar region from the 1st to the 5th vertebra with the minimal inclination usually 20 to 30 degrees in the upper lumbar area and 40 to 50 degrees in the 5th lumbar region. Asymmetry with frontal facets on one side and sagittally placed facets on

the opposite side, occurred particularly in the 5th lumbar vertebra, in 6 of 75 cases observed by Putti

The anatomical potentialities of the articular facets in the production of low-back pain, with or without sciatic radiation, are obvious, but pathological evidence is not yet sufficient to prove it In cases of low-back pain clinical evidence of pathological changes in, or affecting the articular facets, requires serious consideration of the articulation in all cases The frequency of arthritis in the facets as age progresses, and the frequency of low-back disturbances in similar age periods, are coincidental facts of significance

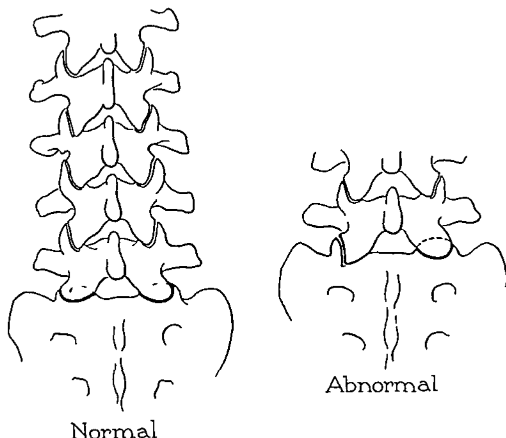


FIG 127 —Lumbar and lumbosacral articular facets (Redrawn from Putti)

The role of the facets should be considered in every case of sciatic syndrome Rotation of the lumbar, and particularly of the lumbosacral articulation, takes place chiefly in the facets, instead of in the intervertebral disks as it does during rotation of the thoracic region

The importance of the facets in the production of sciatic pain has been emphasized by many authors Putti advocated the use of stereoscopic roentgenograms to demonstrate pathological changes in the facets In the same year that Meyer-Burgdorff's monograph appeared, Hubeny described the advantages of the oblique position for roentgenography, in demonstrating the lumbosacral facets The important points to be observed are narrowing of the space between the articulating surfaces of the facets,

marginal proliferation about the articulating surfaces of the facets indicating hypertrophic changes, or in many instances, traumatic arthritis, fractures through facets or through the adjacent laminæ and pedicles, increased or decreased radiability of the bony structures making up the facets and their supporting structures

FACET DISORDERS AND DERANGEMENTS
THE FACET SYNDROME

Internal derangements of the back bear some striking analogies to those of the knee These can be illustrated by the adjectives inadequate insufficient undependable insecure unpredictable

Facets and foramina have been given too little attention in the over-all back and neck problems If one will examine an articulated skeleton of the spine he will be impressed with the remarkable intricacies and minutia of detail that must work precisely during the simple movements of flexion and extension There is a strong resistance to lateral and rotatory movement analogous to that of a knee joint It is only by the ability of each segment to give a little that the combined effect of many, permits any lateral and rotatory movement of the vertebral column

If the mechanics of the facets are disturbed or deranged, one can anticipate recurrent troubles

Degeneration of a disk leads to instability of at least one vertebral body which is followed by secondary mechanical disorders of the local intervertebral joints, foramina and nerves

According to Yount the lumbosacral facets face mainly dorsoventrad The fourth and fifth have a slight inclination toward lateral facement Thus it is apparent that appreciable motion can take place only in the dorsoventrad direction and that there is strong structural opposition to rotation movements

Function—The facets are very important weight sustainers Their integrity determines the possibility of vertebral movements

Pathologic changes include Mechanical alignment fractures dislocations synovitis facetitis facetosis

The chief *symptoms and signs* are pain and limitation of movements, especially extension

X-ray studies include routine AP and L projections which are scout films Special obliques are very helpful especially in visualizing the facets and foramina

Observations to be made include Facets 1 alignment 2 smoothness 3 clarity

Foramina 1 size 2 alignment 3 smoothness 4 clarity Interpretation of the films includes alignment

Incongruity of facets malalignment of facets synovitis destruction of cartilage

LUMBAR FACETECTOMY

Facetectomy is attended by a definite risk Failure to look for a subarticular prolapse before spinal fusion may result in burial of a prolapsed disk This may be one of the causes of chronic pain and discomfort

Hirsch reported on 23 lumbar facetectomies It is not an operation to be undertaken lightly He recommends supplementary fusion

If the intervertebral foramina or the articular facets are encroached upon destroyed or weakened it will lay the groundwork for future serious mechanical trouble Facet derangements are prone to produce sudden attacks of acute locked back In the thoracic region a facet derangement may take one s breath away '

The lesions involving the facets are synovitis arthritis malalignment fractures and dislocations Discussions about the joint synovia or capsule refer to the intervertebral joints

The joint capsule of the articular facet lies immediately posterior to the nerve at its exit and forms part of the posterior wall of the foramen

Synovectomy is not practical except when doing a fusion operation The injection of Compound F into vertebral parts is difficult and impractical unless one has a wide exposure

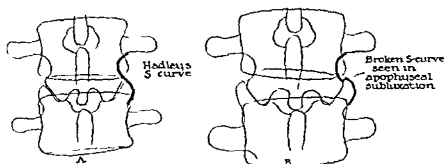


FIG 128 —Hadley s S-curve A Normal A P view showing S-curve which follows the lower border of the transverse proce lateral margin of the inferior articular process extends a ross the apophy eal joint along the lateral margin of the adjoining superior articular process B Thinning of disk cau ing subluxation of apophy eal articulations resulting in broken S-curve Pain under such conditions can be cau ed by (1) strain upon ligamentous structures (2) disturbance of relationship of articular surfaces (3) encroachment on the intervertebral foramen (4) actual bony impingement between articular proce s and pedicle above or lamina below (Redrawn from roentgenograms)

Hadley s S-curve —In the antero-posterior view centering through an intervertebral disk of normal thickness in the lower lumbar region, an S-curve is formed the line following the under-surface of the transverse process and the lateral surface of the inferior articular process, and extending across the apophyseal joint and along the lateral surface of the superior articular process from the body below (Fig 128) This curve is seen best if the plane of the articulation is nearly sagittal In case there is an apophyseal subluxation with thinning of the disk, such a view shows a jog in the S-curve at the point where the posterior articulations have slid past each other (Fig 128)

THE HYPERACUTE EXTREMELY PAINFUL "LOCKED BACK" SYNDROME

Occasionally a physician encounters a case of hyperacute, extremely painful back with excruciating pain radiating down one or both legs and

distortion of the torso and pelvis, the patient being in such agonizing pain, and his tissues so sensitive that a satisfactory examination cannot be made. If he can stand he lists to one side and has a scoliosis. One of my patients said "My cargo has shifted."

The pain in the back is variously characterized as "terrible," "terrific," "unbearable," "extreme," "devastating," "hyperacute," "exquisite." Severe sciatic radiation pain often accompanies such an attack. During a remission, the apprehension of the victim may result in muscle spasm of the highest degree. I have referred to it as "sledge hammer" backache and as probably the only condition that can stifle a sneeze. Such patients transmit an impression of impending disaster. They do not know when it is coming, what is coming or from what direction it may come, but they all know it will produce its devastating effect in the lower back and the lumbosacral nerves.

Few orthopedic conditions evidence such severe symptoms and physical signs. The lesion is usually a protruded intervertebral disk or a subluxation of an intervertebral articulation. As a lightning type of attack it may well be termed a "blitz." It affects men more often than women.

An exact anatomical or etiological diagnosis is often impossible. Hence, diagnosis must be based upon a history of repeated attacks and the condition in which the physician finds the patient. Differential diagnosis may involve a disk lesion, a spinal cord tumor, an aneurysm or the rupture of a vertebral artery or vein.

The background of these cases is so similar that the physician who has seen a number of them can anticipate many of the patient's previous activities. The type of person vulnerable to these attacks is usually the overworked man between forty-five and fifty-five years of age, who for years has been under mental and physical strain. He has discontinued all athletics, and sports, occasionally "kicks over the traces," goes to a cocktail party and dance. He is usually overweight with a low basal metabolism. He eats too much purine-forming food and is practically "gout imminent," he has previously had several attacks of lumbago, subacromial bursitis, and painful feet. He is usually a "heel walker" who has been guilty of dietary and other discretions.

Hospitalization makes possible immediate and intensive treatment for such a patient. He should be given a hypodermic of ½ grain morphine immediately or pentothal sodium intravenously for the relief of pain and to secure sufficient relaxation of muscle spasm to permit even a cursory physical examination.

Paravertebral anesthesia with novocaine is in many cases desirable. If relief is not accomplished, it is practically positive proof that the condition is due to a space-occupying lesion in the spinal canal such as a protruded intervertebral disk, a spinal cord tumor, or a ruptured blood vessel. Injections of novocaine directly into painful areas often help. A gentle examination, manipulation and traction are carried out while the patient is under the anesthetic. Intravenous tolserol is usually very effective.

As soon as the acuteness of the attack has subsided a complete examination may be made. Roentgenograms should be taken to rule out osteomyelitis, tuberculosis, malignancy or other serious lesions.

Continuous pelvic and leg traction should be maintained during and after the anesthesia When the patient is put back into bed on a rigid mattress it will now be possible to lay him flat on his back The degree of traction should be commensurate with his weight (sometimes up to 15 or 30 pounds) The pelvis and trunk should be strapped with adhesive or secured by a belt or a scultetus binder Traction should be applied by means of a belt and ropes attached to weights and passing over pulleys Traction should be applied to each leg, whether the lesion is unilateral or bilateral The foot of the bed should be elevated about 8 inches so that the body exerts countertraction to the weights Large amounts of salicylates by rectum (as much as 60 grains of sodium salicylate) should then be given A daily intravenous injection of at least 100 mg of vitamin B_1 is also prescribed Heat should be applied locally and continued if it relieves him

Certain persons in forward flexing of the back are suddenly seized with severe pain and upon examination are found to have extreme muscle spasm and paroxysms of severe pain on the slightest movement Relief can often be given these patients by ethyl chloride spray and the application of a tightly fitting lumbosacral support

THE INTERVERTEBRAL FORAMEN—SUBLUXATION OF APOPHYSEAL OR INTERVERTEBRAL ARTICULATIONS

The foramina have not been given sufficient attention They are very important as transmitters of the spinal nerves

The usual signs and symptoms of foramen disorders are

1 pain from pressure
2 limited movements from pain

X-ray films are usually not too helpful Rest and flexion and immobilization afford relief of spasm Surgical treatment includes decompression of foramen which removes one jaw of the compressive 'nut cracker' force

Disturbances in and about the intervertebral foramen as a cause of pain in the back have recently occupied the attention of various authors Sicard portrayed the intervertebral foramen as the "cross roads of neuralgia"

Anatomically, the foramen's anterior boundary includes parts of the vertebral bodies and their interposed disk, above and below are the pedicles posteriorly the foramen has the superior and inferior articular processes with the apophyseal articulations between them These latter are true diarthrodial joints with a joint cavity articular cartilage synovia and capsule, and are subject to the multiplicity of disturbances which may involve any joint Hadley emphasized apophyseal joints of the spine as true joints, likely to be painful at times as a result of arthritis or trauma Lumbar lordosis places increased weight upon the posterior spinal articulations and increased strain on their capsules Ghormley mentioned arthritis of these joints as a cause of pain in the back, while sprains, with or without tearing of the ligaments have been noted as a frequent cause of post traumatic back pain

Thinning of the intervertebral disks either by herniation of the nucleus pulposus or by fibrotic degeneration, allows the vertebral bodies to approach

one another This may produce pain by strain upon the capsules, encroachment upon the size of the intervertebral foramen or by impingement of the ends of the articular processes, either against the pedicle above or the lamina below

The apophyseal intervertebral articulations may become directly involved, as affections of the vertebral bodies spread to the articular processes, or indirectly, when by abnormal positions of vertebræ unusual stress is placed upon the articular facets These articulations may become affected by the various forms of arthritis, primarily, independently, and exclusively

Oppenheimer discussed the influence that variations in the thickness of the intervertebral disk have on the foramina When the space between the vertebræ diminishes in proportion to the degree of thinning of the disk, the decrease in height of the foramen is due to the narrowing of the interspace, while the resulting forward displacement of the superior articular process of the subjacent vertebra produces a decrease in the lateral diameter The narrowing of the foramen thus caused is sufficient to account for marked compression of nerve roots

The weight instead of being borne entirely by the vertebral bodies is partially supported by the remaining articulations of the spine which shift the strain on to the capsules This not only produces pain but decreases "the factor of safety in motion" When thinning of the disk takes place in the thoracic region, kyphosis results, possibly because the articulations of the ribs do not allow slipping of the posterior articulations

VERTEBRAL APOPHYSEAL IMPINGEMENT

Vertebral apophyseal impingement is a mechanical condition due to impingement of spinous processes It has been called the "kissing apophysitis" based on a postural disturbance In the roentgenogram the spinous processes appear to have insufficient clearance-space during spine movements In reality the interspinal space contains tissue that is sensitive when compressed The treatment is removal of one of the involved processes

APOPHYSEAL BURSITIS

Apophyseal bursitis is due to inflammation of the bursæ between the spinous processes It may be due to acute or chronic trauma, especially blows, falls pressure from braces and sitting against hard surfaces It causes pain, tenderness and limitation of movements, especially in flexion and extension After novocainization to prove the cause, the treatment is surgical excision of the bursa

Continuous pelvic and leg traction should be maintained during and after the anesthesia When the patient is put back into bed on a rigid mattress it will now be possible to lay him flat on his back The degree of traction should be commensurate with his weight (sometimes up to 15 or 30 pounds) The pelvis and trunk should be strapped with adhesive or secured by a belt or a scultetus binder Traction should be applied by means of a belt and ropes attached to weights and passing over pulleys Traction should be applied to each leg, whether the lesion is unilateral or bilateral The foot of the bed should be elevated about 8 inches so that the body exerts countertraction to the weights Large amounts of salicylates by rectum (as much as 60 grains of sodium salicylate) should then be given A daily intravenous injection of at least 100 mg of vitamin B_1 is also prescribed Heat should be applied locally and continued if it relieves him

Certain persons in forward flexing of the back are suddenly seized with severe pain and upon examination are found to have extreme muscle spasm and paroxysms of severe pain on the slightest movement Relief can often be given these patients by ethyl chloride spray and the application of a tightly fitting lumbosacral support

THE INTERVERTEBRAL FORAMEN—SUBLUXATION OF APOPHYSEAL OR INTERVERTEBRAL ARTICULATIONS

The foramina have not been given sufficient attention They are very important as transmitters of the spinal nerves

The usual signs and symptoms of foramen disorders are

1 pain from pressure
2 limited movements from pain

X-ray films are usually not too helpful Rest and flexion and immobilization afford relief of spasm Surgical treatment includes decompression of foramen which removes one jaw of the compressive "nut cracker" force

Disturbances in and about the intervertebral foramen as a cause of pain in the back have recently occupied the attention of various authors Sicard portrayed the intervertebral foramen as the "cross roads of neuralgia

Anatomically the foramen s anterior boundary includes parts of the vertebral bodies and their interposed disk, above and below are the pedicles posteriorly the foramen has the superior and inferior articular processes with the apophyseal articulations between them These latter are true diarthrodial joints with a joint cavity articular cartilage synovia and capsule and are subject to the multiplicity of disturbances which may involve any joint Hadley emphasized apophyseal joints of the spine as true joints, likely to be painful at times as a result of arthritis or trauma Lumbar lordosis places increased weight upon the posterior spinal articulations and increased strain on their capsules Ghormley mentioned arthritis of these joints as a cause of pain in the back while sprains, with or without tearing of the ligaments have been noted as a frequent cause of posttraumatic back pain

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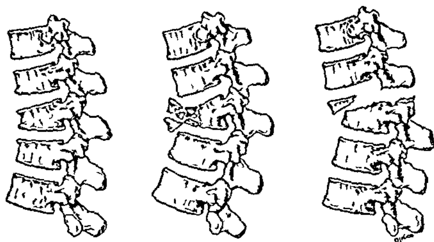


Fig. 130.—Types of fractures of the vertebræ. (R. Watson-Jones, courtesy of Brit. Med. Jour.)



Fig. 131.—Compression fracture of thoracic vertebræ producing a total round kyphosis

CHAPTER 21

FRACTURES OF THE VERTEBRAE

Fractures of the vertebrae are increasing in numbers and severity, due to recent over speeded mechanical, industrial and military pursuits. An early diagnosis can be made more reliably because the medical profession is more keenly alive to the injury, roentgen apparatus has been improved and is more widely available and there are more trained roentgenologists. Earlier and better treatment is given to fracture victims because of improved transportation and standardization of procedures.

Localization of Spinal Injuries. — Jefferson's graph (Fig. 129) of the localization of spinal injuries in 2006 recorded cases, revealed that the three most vulnerable points in the spine are the 2d to the 4th, 5th, or 6th cervical, the 12th thoracic and the 1st lumbar vertebrae.

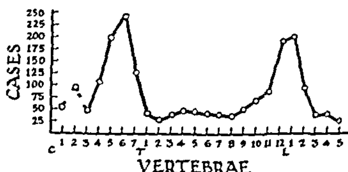


Fig. 129. — Graph of the localization of spinal injury from 2006 cases in the literature. Note the critical points. There are two peaks of frequency, one cervical, the other thoraco-lumbar. (Geoffrey Jefferson, Proc. Roy. Soc. Med., 1928, 21, C. 5, Sect. Orthop.)

The causes of vertebral fractures are traumatic and pathological. Their mechanogenesis includes direct and indirect factors. The direct factor is a blow or fall. Indirect factors operate through leverage or torsion. Multiple fractures occur in train or automobile accidents, during industrial and military operations, or from cave-ins of mines. Pathological fractures occur in the presence of bone lesions, neoplasms, osteoporosis and certain paralytic lesions, and are associated with changes in intervertebral disks, fasciae, muscles, blood vessels and nerves.

The most common causes of traumatic fractures of the vertebrae are blows on the head or the flexed back, falls on the head, feet or back, crushing injuries, especially those of the jackknife type sustained by miners in cave-ins, and by railroad brakemen riding on the tops of boxcars which go through tunnels or under bridges. The majority are due to forcible flexion of the spine caused by an indirect mechanical force.

When the body of a vertebra is crushed or flattened, it is described as a "compression" fracture. Such fractures are caused by severe violence applied through the long axis of the spine or while the spine is forcibly flexed. A large number of compression fractures due to force of the latter type are the result of automobile accidents in which the head of a person sitting on the back seat, hits the top of the automobile when the car suddenly strikes a bump or collides with another object.

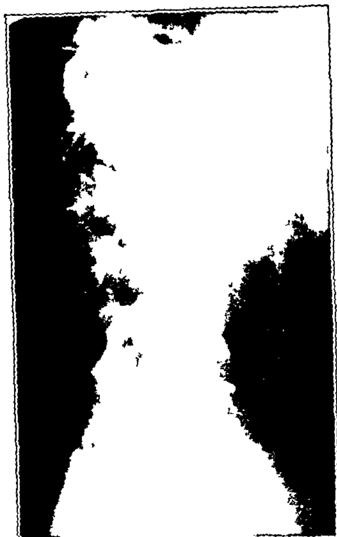


Fig 132 —Compression fracture of 1st lumbar vertebra

Signs and Symptoms — Vertebral fractures may cause few clinical signs in the early stages. The symptoms are pain, tenderness, disability and deformity. Tenderness over the site of injury is the most frequent and positive sign. Shock is indicative of complicating injuries. Injury to the spinal cord due to hemorrhage, edema, or persisting bone pressure is common. Early symptoms and signs of compression fracture of the spine may be obscured by the general shock caused by the accident and the pain of associated bruises or fractures. Muscle spasm is common.

Compression fracture should be suspected in all spinal injuries. Wallace reported that in 70 per cent of a series of cases observed by him the diagnosis had not been made before he saw the patients. Compression fractures of the bodies of vertebræ are easily overlooked owing to their relatively mild symptoms and the absence of physical signs. In all cases of pain in the spine following an injury, roentgenograms of the vertebræ should be taken and if the lateral view is not clear it should be repeated. If the films reveal no fracture and the pain persists when the patient walks, another lateral film should be taken and the closest clinical observation maintained.

Usually there is no nerve involvement or cord pressure but the back is weak, stiff and painful. A kyphos does not always appear immediately. Physical examination reveals a flexed attitude, tenderness, sensitiveness to movement and inability to extend the spine.

Great violence is not necessary to produce fractures Sometimes they are produced by slight force The usual history includes one of the following accidents a *fall*, the patient landing upon his feet or buttocks, or upon the head, neck or shoulders, an *automobile accident* the patient having been thrown against the car or to the ground, a *dive* into shallow water the patient having struck the back of his head or neck upon the bottom a *blow* or a heavy object falling upon his head, neck or shoulders when the spine is flexed In military services the causes of fracture are motorized equipment with tremendous speed the heavy vehicles tanks trucks airplanes and parachute injuries

In 1938 Stalker reported a case of double vertebral compression fracture from convulsive therapy In 1939 Bennett and Fitzpatrick reported a case of compression fractures of the 11th and 12th thoracic vertebrae complicating metrazol therapy Dedichen observed such fractures in 6 of 80 cases treated in his hospital similar fractures have been noted in other hospitals They occur during the tonic stage and resemble those seen in tetanus The anterior part of the vertebra is compressed without injury to the spinal cord There is a slight gibbus The fracture usually occurs between the 3d and the 9th thoracic vertebrae They can be largely prevented by not allowing the patient to double himself up during attacks

Evans divides fractures of the spinal column into three anatomical groups (1) fractures of the transverse and spinous processes which serve for the attachment of muscles (2) fractures of the vertebral bodies which transmit weight and (3) fractures of the laminae articular processes and pedicles which form the neural arch behind

Westerborn and Olsson consider the following varieties of spinal fracture and the mechanics involved

1 Extension fractures
2 Flexion fractures and
3 Fractures of the neural arch

Flexion fractures may be (*a*) anterior wedge fractures (*b*) lateral wedge fractures and (*c*) fracture-dislocations

Most fractures are sustained while the spinal column is in flexion In many cases complete paraplegia following an injury in which no bony damage can be demonstrated in the roentgenograms has been shown to be due to hyperextension injuries with rupture of the anterior longitudinal ligament and then spontaneous reduction

Mechanism —Jefferson compares the vertebral column to two parallel fused cylinders the anterior of which consists of the vertebral bodies and intervertebral disks the general purpose of which is to support weight The posterior cylinder consists of an interrupted articulated column of neural arches protecting the spinal cord From these neural arches are thrown out a number of transverse and spinous processes which serve chiefly as struts for muscular attachments When the spine is compressed from above the anterior column gives way more rapidly than the posterior because of its spongy bone and intervertebral fibrocartilage

The tendency of the vertebral column to flex when it is compressed is enhanced by the protective reflex through which an unexpected touch on the head causes instantaneous and involuntary bending forward (the Magnus "Duck your head" reflex)

Adolescents may show irregular ossification of the epiphyses at the caudal and cephalic ends of the vertebral bodies, so-called osteochondritis vertebralis. The lesion is usually multiple and must be distinguished from fracture.

Laboratory Studies.—Blood counts are advisable. The urine should be examined to determine the presence of bladder or kidney injury.

Diagnosis.—The diagnosis of vertebral fracture is based on the history of injury, the presence of pain, disability, deformity and roentgenographic changes. The spine should be examined for fracture in every case of pain, soreness, or stiffness in the back following an injury, and absolute rest should be insisted upon until the examination is complete. The examination should be as thorough as possible without causing additional injury. It should be begun with painless procedures. The nature of the trauma causing the fracture and the patient's history with regard to disease and to previous injuries and diseases, should be considered. The surgeon should not be deceived by the absence of deformity or disability. Roentgenograms of wide areas in two planes should be made as soon as possible. A search should be made for more than one fracture. In the differential diagnosis, it is important to rule out Calvé's, Schmorl's, Kummell's and Charcot's lesions. Any injury to the spine may light up a pre-existing pathological condition.

Complications.—Complications may occur in the spine, the spinal cord, or extra-spinally. Those of the spine and spinal cord include vertebral dislocation and spinal cord injury. Frequent extra-spinal complications are fractures of ribs and of bones of the extremities. Fracture of the os calcis is a fairly common accompaniment. Other complications are shock, injury to nerves and blood vessels, fat embolism, defective union, contractures, deformity and hysteria.

Healing of Vertebral Fractures.—Normal bone possesses great power of repair. There is, however, a striking difference between the healing of vertebral fractures and those involving the long bones. After the primary deposition of calcium the local supply of calcium is obtained from the blood, there is a constant interchange between the calcium-phosphorous content of the bone and that of the blood. The calcium held in the blood as a calcium-carbono-phosphate in a colloidal solution is precipitated in the bone as a triple calcium phosphate and calcium carbonate. Half of the calcium concentration in the blood is bonded to proteins as calcium proteinate. A high protein diet favors elevating the blood-calcium level, particularly if below normal, and maintains it at a higher level. Protein injected locally in the form of tissue fibrinogen has a similar effect.

The metabolism of calcium in the bones is controlled by the parathyroid glands. In the blood of the normal adult the relation of calcium to phosphorus is in the proportion of 10 to 3.5 mg. per 100 cc., giving a coefficient of 35, which is known as the "calcium-phosphorus index."

As the normal course of fracture repair involves a decrease in the phosphorus content of the blood, bone repair may be a process of phosphorization rather than of calcification. Robison *contends* that the enzyme associated with bone *repair* hydrolyzes the phosphoric esters of the blood liberating phosphate ions. This enzyme is found in cartilage, young bone, the teeth of young animals, and the kidneys.

Roentgen ray Findings — Traumatic lesions of the spine are of increasing frequency since the development of high-speed transportation Dislocations are more common in the cervical region, and fractures in the lumbosacral region In almost all lesions accompanied by dislocation the upper segment of the spine is displaced forward Fractures may involve one or more parts of any vertebra In order of frequency, Garland lists the parts fractured as the vertebral body, the transverse processes, the articular processes, the lamina, and the spinous processes

The roentgen ray reveals the fracture and its type Postural roentgen ray distortion may exaggerate or minimize the local situation During the healing of the fracture the roentgen-ray findings are always chronologically behind the condition It is unwise to show films to the patient or his relatives or friends Juries should be informed that roentgenograms are not the all-determining factors in arriving at a just verdict

It is important that antero-posterior and lateral projections be taken immediately A stereoscopic examination should be made if doubt remains When a fracture is present, the antero posterior film will usually reveal a diminution of the height of the affected vertebral body As a rule the lateral film will show in addition an anterior projection of the body beyond its normal confines Vertebral fractures may be found at different levels

Conwell points out that in some cases in which roentgenograms made immediately are negative, subsequent roentgenograms reveal collapse of a vertebra Fractures in the posterior portion of the spinal column may easily remain undiscovered

The patient may be roentgen-rayed while he is on a Bradford frame In order to minimize the trauma incident to transfers the stretcher is taken directly to the roentgen-ray table

Fractures of the body of the vertebra may be transverse, vertical or marginal The fracture line is usually most evident in the anterior part of the body and best seen in the lateral projection It is frequently associated with vertical narrowing or compression which is usually most marked anteriorly Recent fractures appear as sharp, irregular lines and the lateral margins of the vertebral body are usually smooth

Fractures of the anterior margins of the vertebral bodies must be differentiated from congenital persistent ring epiphyses Garland emphasizes the differential value of the smooth nature of the cleft in the case of a congenital lesion and the absence of signs of reparative changes after an interval of four weeks

In infants there is normally a horizontal cleft in the mid portion of the vertebral bodies conspicuous in the thoracic area The cleft is most marked anteriorly and is due to incomplete ossification of the intersegmental zone of the vertebral body It rarely persists into adult life as a transparent intersegmental septum A similarly located line widest posteriorly, occurs in the vertebral bodies of about 25 per cent of adults This thin transparent line does not extend through the anterior margin of the body, and is due to a channel for the vertebral arteries and veins—the horizontal vascular channel Such *channels are frequently mistaken for fractures* They show no change after an interval of weeks

by immediate reduction of the compression The automobile-jack hyper-extension method provides an excellent anatomical reduction of the injury The time in bed and hospitalization are shortened by adequate reduction Spine fusion is unnecessary for most acute fractures

Many of these injuries have industrial, insurance or medico legal implications The period of active treatment varies from six to twelve months The average patient will not be expected to return to work in less than twelve months Furthermore, there may be late sequelæ requiring treatment that will be declared compensable

A general rule is to allow 20 per cent total disability if, on final recovery, there is useful strength and motion up to 75 per cent of normal, with relative freedom from muscle spasm and pain

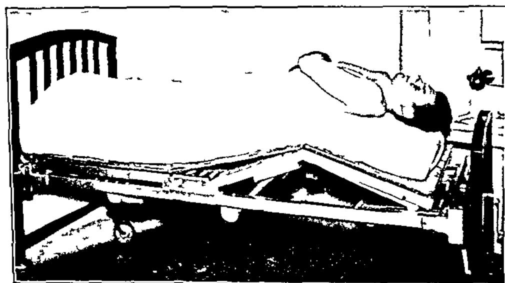


Fig 133 —Baker s modification of Gatch bed for arthritis Useful in fractures of vertebræ Sponge rubber or latex mattress Hinged fracture board Patient s head toward foot of bed (Baker courtesy of Jour Bone and Joint Surg)

Treatment of Fractures of the Vertebræ

Much progress has been made in the treatment of fractures of the vertebræ during the last decade

Recent improvement is due to expert supervision, simplicity of apparatus team work, segregation of cases, and proper after-care

Chief aims in the treatment are relief from pain deformity and future disability It is more important to restore function than form Restoration of the form of the vertebræ does not always assure restoration of normal function

Successful treatment requires knowledge of the anatomy and mechanics of the back, selection of the most appropriate procedure for the particular situation with constant and meticulous attention to details

Initial treatment is most important Complete rest minimizes muscle spasm and other complications and also facilitates healing

Phemister is of the opinion that phosphorus, given during the period of active repair, will stimulate callus formation and ossification As compared with the endosteum and cambium layer, compact tissue takes but little part in the formation of new bone, it acts as the scaffolding on which the new bone is laid down Repair is most rapid where cancellous tissue is most abundant, or mobility is slight, as in the vertebra

Prognosis —The factors determining the prognosis are the patient's age and general condition, the type of fracture, the presence or absence of complications and the length of time elapsing between the injury and the beginning of treatment The psychological reaction of the patient is important The nature of the patient's work and his insurance compensation or military coverage influence the duration of disability

The severity of the injury, the presence or absence of shock, cardiac and renal efficiency, and nerve injury, also affect the prognosis Priapism is an unfavorable sign Excellent functional results are frequently obtained, even in cases of severe comminuted vertebral fractures

In a series of 100 cases of acute fracture of the spinal vertebræ without spinal cord injury, Conwell found that the incidence of permanent total disability was 23 5 per cent Of 62 patients who had sustained industrial accidents 34 7 per cent had permanent total disability, 25 returned to full duty without any permanent disability 20 resumed light industrial jobs, and 12 who averaged 64 5 per cent permanent total disability were unable to return to industrial work of any kind Five cases were rated 100 per cent permanent total disability

The prognosis as regards life depends upon the presence or absence of complications especially in the spinal nervous system and urinary tract infection Murray finds that a fusion operation is ultimately required in about 15 per cent of cases

Fikenbary reported that he had seen more than 100 cases of fracture of the spine and that in not one instance in which a fusion operation was performed, was the patient able to return to strenuous work

According to Hall fractures of vertebral bodies and transverse processes have been overrated as bases of disability largely because of poor psychotherapy and improper treatment

The psychological reaction of the patient is of special importance in the prognosis of spinal injuries The sooner the patient is freed of the fear of permanent total disability the better will be the functional result The psychological effect of complete reduction and healing of the bone is of major importance in industrial and medico-legal cases

Fractures of the spine with immediate complete transverse myelitis indicate a hopeless prognosis

Hudson advises that every injury to the back with signs and symptoms that imply wedging of the body of the vertebra should be considered a fracture, a therapeutic reduction test should then be given, for a recent compression may be easily corrected An old fracture will probably remain unchanged

Conservative treatment offers the patient an excellent outlook for recovery Complete immediate reduction of the fracture with immobilization should be secured Abdominal symptoms are reduced *to a minimum*

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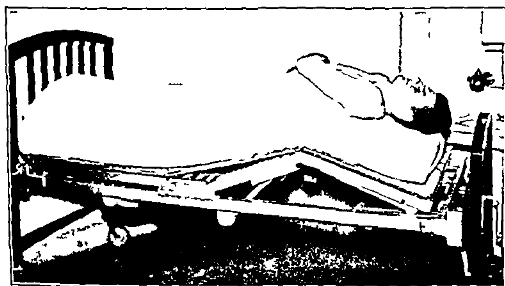


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Successful treatment requires knowledge of the anatomy and mechanics of the back, selection of the most appropriate procedure for the particular situation, with constant and meticulous attention to details

Initial treatment is most important Complete rest minimizes muscle spasm and other complications and also facilitates healing

Two fundamental principles which Sir Robert Jones maintained must be adhered to, are (1) efficient fixation at the earliest moment, (2) continuity of treatment

Treatment of fractures of the vertebræ includes first-aid, transportation, reduction, retention and rehabilitation

First-aid —In rendering first-aid, care must be taken to prevent additional injury The examination should be gentle with no unnecessary manipulation Shock should be treated and the patient given careful handling and proper support The patient not the fracture should be treated first

Transportation —In all injuries to the spine the patient should be transported face downward If he is carried in this manner the spine is hyperextended This position is not only harmless, but may permit automatic reduction of the displacement during transportation

All general hospitals should be thoroughly equipped for treatment of fractures of the spine Every fractured vertebra should be treated as an emergency It should be possible to call a staff surgeon to the hospital at any time of the day or night to care for a fresh fracture Roentgenograms should always be obtainable

Every fracture of the vertebræ should also be considered an individual problem Treatment should be directed not only to injury of the bone but also to that of the soft parts The best plan seems to be to place the *patient on a Rogers hyperextension frame, administer an anesthetic accomplish gradual hyperextension, apply a plaster-of-Paris cast* and perform a fusion operation through a window in the cast

Collapse of a fractured vertebra may occur even when the patient is under treatment Conwell states that when collapse does occur in fractures which had good position originally and were given immediate proper treatment, the cause is interference with the nutrient blood supply at the time of the injury Operative fusion will usually prevent further collapse

In debatable injuries early studies with systematic follow-up will demonstrate fractures progressing to complete healing or to sclerotic changes, in contrast to anomalies which are unchanged over a similar period

In fractures of the vertebra Orr considers it important to restore the spine at once to correct length by suitable traction and manipulation and to replace all the parts in correct anatomical relationship Evidence of damage to the spinal cord or to the nerve roots necessitates particular care Symptoms of cord damage require immediate surgical exploration, with laminectomy or direct reduction of the fracture Cord injury need not be considered a contraindication for traction and the restoration of trunk and spine to correct position If the patient is given primary care *symptoms of cord injury may be expected to disappear,* and surgical exploration of an unreduced fracture may be avoided The importance of attaining correct position and applying a proper jacket or spine brace before moving the patient is generally recognized

Bohler recommends that compressed vertebral bodies be adjusted early, and that the solidity of the spinal column be improved by exercises The majority of vertebral fractures may be reduced by suspension without manual manipulation at the point of fracture Manipulative reduction

under anesthesia is indicated only when ordinary suspension does not result in complete disappearance of the kyphos and should be done only by surgeons with experience.

In the immediate treatment, operation is indicated only when there is a serious spinal cord injury or the spinal cord is endangered by the pressure of bone fragments. Under such conditions, laminectomy should be performed as soon as possible after the subsidence of shock.

During reduction the gibbus, the apex of which is represented by the tip of the spinous process, must not be permitted to impinge against a rigid object because it may force a fragment of bone into the spinal canal. Such a calamity may be avoided by hyperextension in the prone position obtained by the manipulative hyperextension method.

After reduction one must decide whether to apply immobilization apparatus or perform a fusion operation. In compression fractures complete reduction is not always possible. In anterior compressed fractures of the

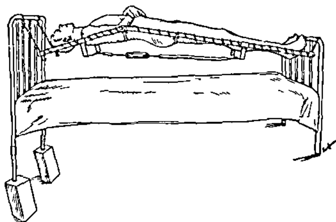


Fig. 133.—Conwell's modification of Herzmark's frame used in reducing anterior compression fractures of the spine. The turnbuckle brings about any desired degree of hyperextension. A body cast is applied later. (Redrawn from Key and Conwell's Fractures, Dislocations and Sprains, courtesy of C. V. Mosby Company.)

vertebræ, Conwell uses general extension of the spine with the aid of a modified Herzmark frame and with increasing gradual hyperextension of the frame to bring about hyperextension of the spine. After reduction he applies a molded plaster-of-Paris body cast.

Complete reduction of fresh crush fractures can be maintained when adequate hyperextension and fixation are accomplished.

Transportation of Patients with Fracture of the Vertebræ.—R. Watson-Jones believes that placing the patient on a stretcher on his back tends to increase the deformity, while if he is placed prone the deformity will be reduced. Ambulance men should be taught to put the patient in the prone position on the stretcher. The advantage of face-down transportation is that the postural movement necessary for reduction is instituted at once so that the risk of injury to the spinal cord is minimized. The disadvantages are that patients suffer from shock and that lying on the face might embarrass respiration. There might be fractures of several ribs with associated visceral injury. First-aid workers cannot be expected to diagnose fractures

of the spine The practice of turning patients over is dangerous If after a severe injury a conscious patient complains of pain in the back and inability to move one or both legs, he should be lifted and carried face downward

Hyperextension Treatment —The value of hyperextension in crush fractures of the vertebræ is recognized generally

Wallace's Method —In 1923, Wallace, who was a pioneer in emphasizing the value of adequate hyperextension, reported 82 cases treated by holding one portion of the vertebra in the correct position and making the other portion straighten out He fixed the lower section (which includes the spine from the site of the fracture down to the feet) by fastening the feet to the bottom of the frame The lower section was held in a horizontal position, and by its elevation the upper section was dropped backward and downward In this manner Wallace obtained extension and counter extension which he maintained with a cast having three points of support, one in the back at the kyphosis and two in front, one high and one low

Davis' Method —According to Davis, crushed vertebræ can be entirely reduced with complete or almost complete restoration of their anterior vertical height The anesthetized patient is laid prone on a low table A suspension apparatus is used to elevate the lower extremities until the pelvis clears the table by several inches The suspension is done in a direction upward and footward, that is, the center of suspension is placed about 12 inches distal to the foot so that the traction is both horizontal and vertical The knees are flexed at 45 degrees, horizontal traction as well as hyperextension being thus obtained and pressure on the posterior arch of the involved vertebra minimized After sufficient suspension has been gained, the knuckle often disappears When the knuckle remains prominent manipulation is made by several quick but measured downward thrusts at the sides of the gibbus to disengage the impaction reduce the fracture and correct alignment

After reduction a posterior padded plaster shell is applied from head to knees The roller is mounted and lashed on with plaster ropes Draw sheets previously placed transversely under the patient, are then drawn tightly around the shell, and the patient is rolled onto his back

An average of seven weeks of shell treatment is necessary The condition is checked by lateral roentgenograms taken through a window in the anterior shell The index of reduction is the degree of anterior vertical thickness of the vertebra During the first two weeks of the after-care a Taylor back brace is fitted On completion of the shell treatment this brace is applied with the patient in the prone position in bed At first it is kept on constantly when he is sitting or standing but may be removed temporarily when he is prone After two or three weeks it is left off entirely during recumbency Before the patient is allowed to go without it, a final lateral roentgenogram is taken

In the majority of a large series of cases in which Davis used this method, complete reduction was obtained The length of time before the patients returned to their former occupations averaged three or four months

Dunlop and Parker Method – At the time that Davis presented his method of reduction for compressed fractures, Dunlop and Parker were

working independently on the problem They employed forcible hyperextension and traction that produced decompression and reduction

The patient is kept in the cast for a minimum of fifteen weeks As long as he remains in it, his body is kept in the supine position After removal of the cast he is fitted with a Taylor back brace to be worn for a year from the time of the injury

Ryerson's Method —Ryerson's screwjack for the spine is a combination of an ordinary screwjack with a simple device that he described in 1907 The head and shoulders rest on boxes, and the buttocks and legs are similarly supported, padded with pillows or folded blankets

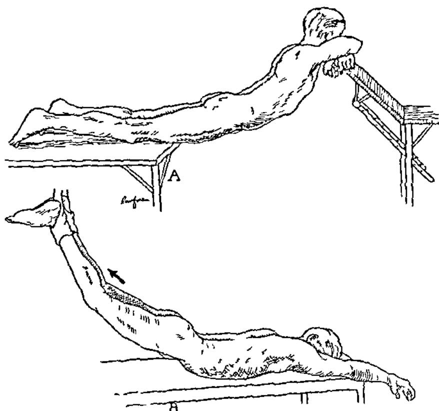


Fig 135 —Means of securing hyperextension of the spine *A* Hyperextension of the spine secured and maintained by two tables of different height (R Watson Jones courtesy of Brit Med Jour) *B* The arrow indicates the direction of pull considered the most effectual to render taut the anterior common ligament and at the same time protect the posterior arch (A G Davis courtesy of Jour Bone and Joint Surg)

A stockinet undershirt has been previously applied, and felt pads are placed over the anterior-superior spines of the ilia An anesthetic is administered if necessary The jack is now elevated to produce any desired degree of hyperextension

Plaster-of-Paris bandages are then applied and reinforced by longitudinal folded strips or "ropes" in front and back

Watson-Jones Method —Watson-Jones proposed a safe and simple method of reducing crush fractures of the spine which does not require anesthesia special apparatus, or skilled assistance, and is ambulatory throughout The patient is placed prone between two unequally high tables so

that his spine gently sags to the normal limit of hyperextension (Fig 135) The lower table supports the lower limbs, and the higher table the head and upper limbs Neither manipulation traction nor direct pressure is employed As the patient lies between the tables a plaster jacket extending from the groins to the neck is applied When the normal limits of hyperextension are reached weight is taken from the front of the vertebral bodies, the intervertebral spaces are opened anteriorly, the anterior common ligament is put on the stretch and the tension of the ligament is such that a vertebra crushed into a wedge is restored to its original shape If a patient with crush fractures of the vertebra within a few days of the injury lies prone with hyperextended spine supported only by his arms at the side of his head and by the front of his thighs and legs leaving the trunk entirely unsupported the body weight alone is often sufficient to restore the vertebra that has been crushed into a wedge Plaster is then applied

Evans Method —Evans puts the patient under deep anesthesia for complete relaxation and hyperextends him into a swan-dive position by suspending the body from the feet with the chest supported The operator's right arm is then placed under the pelvis at the anterior-superior spines and gradually increasing force is applied to the kyphos with the left hand until complete re-alignment is palpable

Rogers Method —Rogers corrects deformity of the vertebral body by extension of the spine beyond the point at which the anterior ligaments and the disks come under tension The apparatus used by Rogers is essentially a Bradford frame except that spring steel bands, broadside horizontal are employed instead of pipe or tubing The bands can be bent to render the frame concave or convex but will not bend toward one another Chrome vanadium bands preferably $\frac{3}{16}$ inch by $1\frac{1}{4}$ inches are recommended Canvas is stretched tightly across this frame and the patient lies upon it in the dorsal position As the frame is rendered more and more convex the spine is progressively extended

After correction has been obtained the patient is placed on a Bradford frame or provided with plaster shells for a period of eight weeks At the end of that time a plaster jacket is applied with the spine in extreme hyperextension, obtained preferably with the aid of Goldthwait irons The ambulatory phase of the treatment is then begun Excellent lateral roentgenograms of the fracture can be made through a window cut in the side of the plaster jacket opposite the involved vertebra By taking these roentgenograms before and one week after starting the ambulatory stage a check on the efficiency of the jacket is obtained

After-treatment of Vertebral Fractures —In the after-treatment of fractures of the spine an effort should be made to maintain the tone of the muscles of the back and abdomen Too early weight-bearing, sitting or walking must be avoided Supports should not be removed until there is assurance from physical examination and roentgenograms that the vertebrae can stand the load

Physical therapy should be of the simplest type heat massage and stimulation of muscles by active and passive movements Massage and movements must be carried out carefully and gently Early active movement and massage, by stimulating the blood supply and the production of

callus and prevent adhesions and fibrosis. Active movements affect muscles and mind, usually strengthening both. Voluntary active movements of joints contiguous to a fracture begun as early as possible without disturbing the fracture are desirable. Under-water exercises are of value. Hinton refers patients with fractures to occupational therapy in preference to *physical therapy. Sunlight and diet are factors influencing the calcium* and phosphorus content of the blood. In certain cases of delayed union, the administration of yellow phosphorus, cod-liver oil, and calcium preparations has apparently aided osteogenesis.

Nicoll described 4 types of fractures and fracture-dislocations of the thoraco-lumbar spine.

Anterior wedge fracture
Lateral wedge fracture
Fracture-dislocation
Isolated fractures of the neural arch

He called attention to a special type of anterior wedge fracture, in which the whole of the vertebral body is evenly compressed. This "concertina" type of compression occurs in older people and there is little or no angular deformity.

Treatment is based on a division of cases into stable and unstable types. In the treatment of unstable fractures he employs the "double clothes'-peg" graft to supplement anterior fusion, care being taken not to extend the spine beyond the point at which anterior fusion would be jeopardized by distracting the bodies. He believes that unless there is firm anterior support any posterior graft will eventually give way. *Nicoll found no grounds* for the assumption that a perfect anatomical result is indispensable to a perfect functional result.

A crushed disk and a ruptured ligament are both incapable of repair and will cause redisplacement and an imperfect anatomical result regardless of how long reduction is maintained in plaster.

In the unstable cases, Nicoll found that sound anterior fusion yielded the most perfect functional results.

Rogers advocated correction of recent fractures of the vertebral body so as to reestablish pre-injury mechanics of the back. Part of this correction is usually lost through the ultimate gradual narrowing of the injured intervertebral disk. The mechanics of correction is accomplished through hyperextension. Complete bridging of bone across the intervertebral region may be apparent as early as four months. Spinal fusion in extension is *indicated in cases of fracture* with dislocation when adequate correction cannot be obtained.

Pais made a comprehensive study based on the treatment of 600 closed fractures of the spine. Reducing the fracture, maintaining the reduction and reestablishing function constitute the basic criteria of the nonsurgical *treatment*. When treatment does not succeed in filling these requirements it may be advisable in some cases to institute operative treatment. This

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should never be immediate or routine, but only supplementary to orthopedic treatment, except in rare cases of interlocking of the articular apophyses, which prevents reduction or intraspinal displacement of bone fragments Surgical treatment may be carried out early when applied within the third week following the trauma

Early surgical treatment has been employed in the form of operative reduction, removal of free fragments, bone transplantation and stabilization The indication for early surgical reduction of fracture-dislocation with interlocking of articular apophyses is generally accepted He limits early bone grafting to the exceptional cases of unstable reduction after articular apophysectomy or of recurrence with resulting grave danger after plaster cast treatment, especially in fracture-dislocation of the first two cervical vertebræ Occasionally he uses a bone graft in cases of comminuted fractures of several vertebral bodies with serious deformity, which cannot be corrected

Pais employs osteosynthesis with wire or metal plate only when the patient cannot stand a prolonged operation He finds early removal of fragments of the arches and of the transverse articular and spinous apophyses unjustifiable

Late surgical treatment consists of removal of fragments and arthrodesis The former is indicated in fracture-dislocation of the first two cervical vertebræ and also of the other five, although secondary displacement in these is less frequent and less serious then in the first two It is also advisable in fractures of the thoracic and lumbar spine, in painful vertebral arthrosis secondary to fracture, if there is no herniated disk, in spondylolysis and spondylolisthesis and in pathologic fracture of the spine from osteoporosis, malacia or neoplasm

Fractures of the Transverse Processes

Fractures of the transverse processes are usually the result of muscular violence, but may be the result of direct trauma In the latter case, they are usually associated with soft tissue injury or even kidney damage Since the function of the transverse process is wholly for muscle attachments, especially the psoas muscle it is important to relieve the tension of the muscles on the fractured or separated process until such time as bony healing has taken place or at least until the torn soft tissues have healed

Quaintance reported 33 cases of fractures of the transverse processes of the lumbar vertebræ which were due to direct external violence or indirect muscular action This mechanism usually occurs while the person is in a position of flexion

Quaintance found that the fractures are usually multiple and when not accompanied by fractures of the vertebral bodies are usually all on the same side The 2d 3d and 4th lumbar vertebræ are most frequently involved The symptoms and signs are those of a severe sprain or contusion of the back The most important symptom is a sharply localized point of tenderness Ecchymosis and swelling may be present Pain,

stiffness, weakness, muscle spasm, and limitation of back movements are significant. In some cases the fracture may be discovered incidentally.

As a rule, disability is due solely to the associated contusion or sprain of the back, and the fracture is negligible so far as its prolongation is concerned. Its duration usually varies between two weeks and six months. In many cases it is influenced as much by psychic factors and the provisions of State compensation laws, as by the severity of the injury. Because of the frequency of traumatic neurosis, it is advisable that knowledge of the fracture be kept from the patient.

Uncomplicated fractures of the transverse processes generally heal completely with recovery of normal function of the back. Bony union usually takes place except where wide displacement of the fragments is present.

Prolonged immobilization is usually necessary. Kennedy's patients were able to walk after an average period of sixteen days. Rest in bed in slight hyperextension, the duration to depend on the severity of the injury, followed by massage and early progressive active and passive motion is indicated. External heat is comforting. Partial immobilization obtained by rest in bed, simple strapping with adhesive plaster, or a properly fitted corset belt, with the back in the normal erect attitude should be maintained until all pain and tenderness have disappeared. Occasionally, early resection of the fractured part of the process is advisable. If the symptoms persist a fusion operation may be necessary.

Bed treatment is advised with special instruction to keep the legs quiet to prevent muscle pull on the detached fragments. A single transverse process injured has less tendency to become displaced and the treatment may last two to three weeks, whereas, if many are fractured, a much longer period of rest is necessary—from four to seven weeks in bed. In cases where the separation has been so great that union has been an impossibility pain may persist.

FRACTURES OF THE ARTICULAR FACETS

Isolated fractures of the articular facets may cause severe local and referred pain and limitation of motion. Suspicion of such a fracture is aroused by localized pain following a spinal injury when other gross lesions of the spine have been eliminated.

Plaster fixation for a period of ten weeks to three months is usually sufficient in early cases. When the diagnosis has been made late or if the symptoms do not subside under rest and support, fusion of the articular facets is advisable.

Mensor's studies indicate that fractures of the articular processes are of relatively frequent occurrence. More complete roentgenographic studies of the spine made in various planes, will reveal previously undiagnosed fractures of the accessory processes as one of the causes of previously unexplained chronic low-back pain following injury. Fractures of the articular processes manifest themselves as irregular linear areas of rarefaction extending transversely or obliquely across the processes. Their detection may require oblique stereoscopic projections. They must be distinguished from congenital persistent separate epiphyses, frequently seen at the tips of the inferior articular processes in the lumbar region, and from overlying

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FRACTURES OF SPINOUS PROCESSES

Fractures of the spinous processes are due to direct injuries to bones, muscles or ligaments and manifest themselves as linear areas of rarefaction or increased density depending on whether or not there is separation or impaction of the fragments They are not uncommon in the cervical and lumbar regions

They must be distinguished (a) from congenital separate centers of ossification at the tips of the spinous processes which usually have perfectly smooth margins, and (b) from areas of calcification in the posterior longitudinal spinal ligament

Treatment of a fractured spinous process is rest and support If healing does not occur, removal of the spinous process is advisable

Garland describes the bony variations and anomalies at the lumbosacral region, consisting chiefly of variations in the shape and size of the transverse, articular and spinous processes The differential diagnosis between anomaly and fracture is occasionally difficult Acquired traumatic lesions show definite marginal changes with the passage of time, and meticulous comparison of good roentgenograms made at intervals of four or more weeks will usually serve to differentiate congenital from acquired lesions

FRACTURES OF THE THORACIC AND LUMBAR VERTEBRÆ

About 80 per cent of vertebral fractures occur in the region of the 12th thoracic and 1st lumbar vertebræ Most lesions of the thoraco lumbar juncture are due to industrial accidents in which great force is applied to the spine, usually at the level of the shoulders or the nape of the neck when it is bent a type occurring particularly in accidents associated with coal-mining and other heavy labor Speed contends that in the thoracic region only the upper borders of the vertebræ are fractured According to Conwell patients with fractures of the thoracic and lumbar vertebræ should be kept in bed on a Bradford frame or in a plaster body cast for from ten to twelve weeks and then in an ambulatory plaster body cast until sufficient healing has occurred which requires about three or four months At the end of that time the cast should be replaced by a Taylor back brace In fractures of the upper thoracic region, the cast should extend over the shoulders

The same principles of treatment apply to fractures of the lumbar spine

CLAY SHOVELLERS' FRACTURE

Hall described 15 cases of fracture of the spinous processes of the cervical or thoracic vertebræ as clay-shoveller's fracture Annan described 8 cases of this fracture-displacement of part of the spinous process of one or more of the 6th or 7th cervical or 1st thoracic vertebræ

In Western Australia the term 'clay-shoveller's fracture has been applied by Hall to a fracture of one or more spinous processes of the lower cervical or upper thoracic vertebræ, occurring in the great majority of cases in relief workers engaged in shovelling clay

bony margin shadows which, when irregular and sclerotic may easily simulate fracture Multiple projections, stereoscopic oblique projections and occasionally laminographic (planographic) projections may be required in special cases Early diagnosis and the institution of adequate conservative treatment, give an excellent prognosis for complete recovery

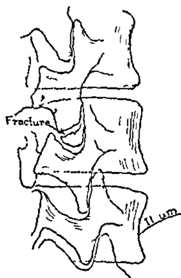


FIG 136 —Fracture of a lumbar vertebra left oblique projection There is an irregular transverse linear defect in the left inferior articular process of the 2d lumbar segment There is a history of recent torsion injury of the back there are clinical symptoms of acute traumatic lesion in the area and the margins of the defect are irregular and not increased in density Therefore the diagnosis is fracture of the left inferior articular process of the 2d lumbar rather than a persistent or unfused epiphyseal line (Mensor M Piersol's Cyclopedia of Medicine courtesy of F A Davis Company)

FISSURE FORMATION IN ARTICULAR FACETS OF THE LUMBAR VERTEBRÆ

The chief clinical importance of facet anomalies lies in their recognition and in their differentiation from fractures of the articular facets

Mitchell found that anomalies show a smooth margin on each side of the fissure, and there is a line of cortical condensation on either side of the smooth fissure, which is not seen in facet fractures No displacement is present in these anomalies whereas it most often is present and distinctly visible in the oblique views in fractures

Embryological study indicates that these anomalies represent failure of fusion of one of the normally present primary ossification centers lying at the base of the articular facet They probably are not anomalous ununited epiphyses or accessory bones

FRACTURES OF LAMINÆ

Fractures of the laminæ may be caused by direct blows or falls but are produced more commonly by hyperextension and sudden severe muscle contractions Congenital non fusion of a lamina is relatively common, especially in the lower lumbar and upper sacral regions Such laminæ tend to be smooth and do not change after an interval of time

FRACTURES OF THE SACRUM

Fractures of the sacrum are usually due to direct trauma The symptoms may be slight and the fracture discovered accidentally Fractures of the sacrum and coccyx generally manifest themselves as linear areas of decreased density Garland finds that overlying intestinal contents, vascular calcifications, and urinary tract and adnexal shadows may simulate fractures in the antero posterior projections Fractures are easily overlooked in this area, and the patient should be prepared by a cleansing enema when the lesion is in doubt Normal marginal sacral epiphyses especially on the lateral margins of the sacrum, must be distinguished from traumatic lesions in the adolescent

FRACTURES OF THE COCCYX

These must be differentiated from congenital variations in the shape and number of the coccygeal segments, the fracture has usually a sharp, linear, rarefied appearance A negative roentgen report does not exclude the presence of fracture

FRACTURES OF VERTEBRÆ IN THE AGED

Vertebral fractures frequently occur in the aged Direct causes are falls or blows Predisposing causes are senility, tumors injuries due to diminished hearing and sight, and lack of agility in getting out of the paths of mechanical vehicles The prognosis is unfavorable, especially in persons with arthritis, diabetes, cardiorenal, pulmonary or peripheral vascular lesions Old persons with fractures must be gotten out of bed if possible, to prevent hypostatic pneumonia Early active movements are desirable

OPEN REDUCTION OF FRACTURES OF THE VERTEBRÆ

According to Campbell, Munro reports an operation for fracture of the spine associated with forward displacement of the vertebra to such a degree that reduction is impossible by manual force The inferior facets of the upper vertebra rest upon the laminæ of the subjacent one and in front of the corresponding superior articular processes The body of the lower vertebra is usually compressed According to Munro, this dislocation occurs most often in the lumbar spine A similar situation is observed in the cervical spine

Munro's Technic —Under local anesthesia, the spinous processes are exposed through a curved incision over the prominence of the kyphos The muscles are separated subperiosteally from the spinous processes and laminæ and the extravasated blood is removed If necessary, the upper spinous process is excised at its base to allow better access to the two superior articular facets The articular process is removed on one side, an assistant then attempts reduction by hyperextension with the aid of a pulley block If this fails, the opposite process is removed and the hyperextension maneuver repeated Reduction is then easily effected The patient is placed in a plaster bed which maintains the hyperextension of

The usual history of the accident is that the laborer throws up a shovelful of clay, the clay sticks to the shovel, and the worker feels a sudden stab of pain and may hear a crack somewhere between the shoulders. He is unable to continue working. The treatment is early removal of the detached fragments.

VERTEBRAL FRACTURE AFTER SHOCK TREATMENT

A vertebral fracture may occur during the tonic stage of shock treatment due to excessive muscle pull. Merten and Bader report that a fracture occurred in 0.1 per cent of 2,000 cases. Vertebral fractures are frequently overlooked and misdiagnosed as muscle tears or muscle rheumatism. The fracture is either a complete compression fracture or an infraction of a vertebral plate.

Of 230 shock-treated patients, 11.3 per cent showed vertebral fractures. Sometimes the x-ray did not reveal a fracture until after the third or fifth treatment. The fourth to seventh thoracic vertebrae are chiefly involved with a preponderance of male patients. Vertebral fractures in epileptics are comparatively rare. A similar pathogenesis is attributed to fractures after tetanus. The number of fractures following electric shock treatment is less than that following chemical shock treatment.

The combination of electric shock and insulin decreases the number of fractures. Curare is generally used for the prevention of fracture. Mertens and Bader emphasize the dangers of a narrow margin of safety in cases of individual sensitivities which may lead to respiratory paralysis. All apparatus for artificial respiration—oxygen and prostigmine—must be at hand. However, patients already having sustained a fracture were subjected to further shock therapy and curare medication. Lately mesantoin has been recommended; 200 patients have received it without complications.

Patients with well developed muscles and between the ages of twenty-five and thirty-five years are especially susceptible to this complication.

These authors advise against passive immobilization. They recommend early weight-bearing in view of the fact that post-traumatic necrosis (Kuemmel-Verneuil) has not been observed. They did not observe disk injuries or did not recognize them.

I feel that protection and support must be provided wherever and whenever a fracture is demonstrated or suspected.

FRACTURES OF THE SPINOUS PROCESSES OF THE THORACO-LUMBAR REGION

Longitudinal splitting fractures of a spinous process are observed, especially in the lumbar region accompanied by tearing of ligaments, and to a moderate degree, dislocation of the articular facets. Fixation in plaster in hyperextension should be followed by roentgenograms to see that re-alignment has been accomplished.

Etiological Factors —By several leading authorities it is now regarded as an unrecognized compression fracture

Davis believes that it differs in no respect from any other compression fracture of the spine, except that reduction is spontaneously affected before the first roentgenogram is taken

Putti thinks that it should be considered as a fracture of the vertebra followed by the same phenomena as attend any neglected fracture in any other part of the skeleton Kümmell himself believed that the syndrome did not always result from a compression vertebral fracture but that in many instances trauma to the vertebral column without compression of

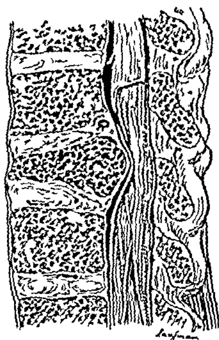


FIG 137 —Kümmell's disease —Sketch of pathological specimen showing rarefaction and collapse of the vertebral body with pressure on spinal cord Result of a fall down an elevator shaft landing on feet NOTE (I interpret the illustration to reveal a disk injury with some protrusion) (Redrawn from Cardis Walker and Oliver)

the bodies was followed by rupture of the blood vessels and injury to the periosteum, causing atrophy of the spongiosa of the vertebral bodies, followed by a gradual compression of the segments producing a permanent kyphosis

Ryerson believes the lesion may be due to cracking of trabeculæ by injury and the seepage of serous fluid which softens them The process is a mechanical or chemical dissolution of the trabeculæ

Kalisko and Schroll explain the lesion as caused by minute injuries to the osseous and ligamentous structures the traumas causing cracks and small hemorrhages

Blaine regarded the initial lesion as a minor degree of compression of a vertebral body, but as careful roentgen-ray examination of the spine, made immediately after injury, shows no fractures of the vertebra, and on later roentgen ray study it is found to be decreased in height, it indicates partial collapse

the spine Each leg is supported on a Braun splint Skeletal traction is instituted by means of a Kirschner wire through the lower end of each femur Fifteen to twenty pounds of weight is applied to each leg

COMPOUND FRACTURES OF THE VERTEBRÆ

In compound fractures of the spine Orr recommends treatment by traction, restoration of contour, open drainage of wounds by the Vaseline pack and an extensive well-fitting plaster-of-Paris cast In the case of osteomyelitis of the lumbar region drainage plus immobilization, even if it is late is effective Orr has had several patients with large abscesses and sequestra (bone grafts sometimes) who had never been immobilized in any way, but whose wounds healed promptly in double spica casts after a proper drainage operation had been done Chemotherapy has improved the treatment and prognosis

Fracture Records —Special record sheets should be used for fractures of the vertebræ Dickson insists on records giving information with regard to the type of injury and fracture, the time that has elapsed between the occurrence of the fracture and its reduction, the condition of the tissues, the roentgenograms taken before and after reduction, the method of reduction the form of fixation the form of traction the type of physical therapy and the time it was begun, the type of convalescent support and the time it was worn the duration of the hospital stay and the period of disability, the anatomical and functional result on discharge and in fatal cases the cause of death

KUMMELL S SYNDROME—POST-TRAUMATIC SPONDYLITIS

Kummell s syndrome is a vertebral lesion due to mild or severe injury, following which the patient usually passes through three clinical stages during the course of a few months or years At the end of this time what appears to be a compression fracture of a vertebra is discovered in the roentgenograms

The syndrome, known by the names of Kummell and Verneuil, was studied by Bonnet in 1857 Schede also called attention to softening of the vertebræ following trauma Kummell in 1891 was the first to definitely distinguish the three stages and to describe their clinical manifestations before the roentgen-ray was discovered In 1894 Kummell reported on 6 cases of this spine lesion which he said had not previously been described Actually Verneuil had described the condition in 1892 and some writers therefore call it the Kummell-Verneuil syndrome It appears to be an unrecognized compression fracture discovered during or after the healing stage The syndrome is of considerable importance to industrial, military and orthopedic surgeons and roentgenologists It may be of great medicolegal import It may simulate a disk syndrome

Various terms that have been applied to this lesion, are post traumatic spondylitis, spondylitis traumatica tarda traumatic vertebral malacia, post-traumatic progressive vertebral collapse and traumatic spondylosis

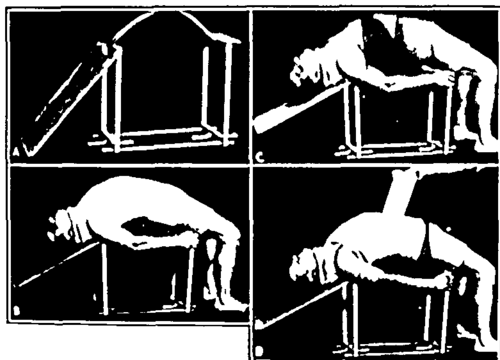


Fig 139 — *A* the Goldthwait irons used in application of the plaster jacket *B* and *C* arrangement of saddlers felt *D* application of the jacket (Rogers courtesy of Jour Bone & Joint Surg)

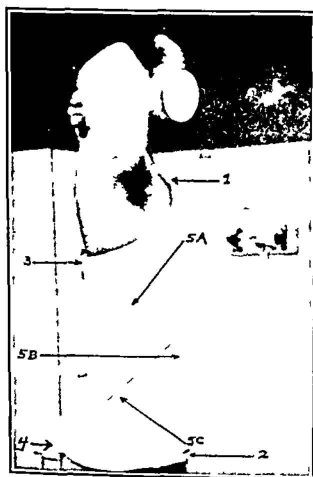


Fig 140 — Three-point pressure jacket (1) Close fit at the sternal notch (2) Lower edge at the symphysis (3) Posterior upper edge below scapulæ (4) Lower edge at the gluteal crease (5) *a b c* direction of thrust (Davis courtesy of Am Acad of Orth Surg)

DISLOCATIONS OF THORACIC AND LUMBAR VERTEBRÆ

Subluxations are of great industrial, military and civil importance Many cases of chronic lumbago are actually residual painful backs following subluxations that were automatically replaced, leaving sore contused muscles and joint surfaces Before reduction can be accomplished it is important to secure complete relaxation Ether inhalation or spinal anesthesia may be required After manipulation, the back should be immobilized by a plaster-of-Paris cast followed by a spine brace, adhesive strapping and belt Immobilization should be followed by physical therapy such as infra-red heat, the Morse wave, diathermy or inductotherm massage, exercises and muscle re-education

FRACTURE-DISLOCATION OF THE VERTEBRÆ

Fracture-dislocations occur most commonly in the cervical and thoraco lumbar areas

The etiological factors are similar to those described under vertebral fractures The general principles of symptoms, signs, physical findings,

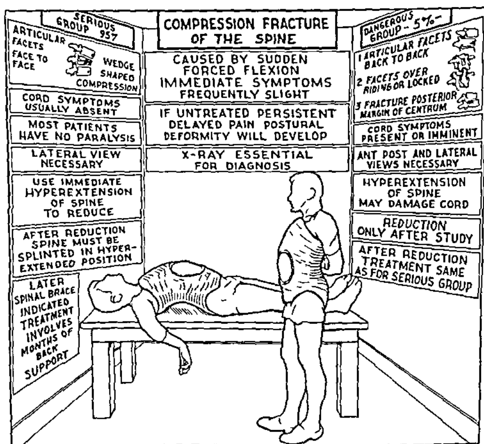


FIG 138 —Compression fracture of the spine Fracture of the bodies of one or several vertebræ may occur as the result of forcible acute flexion of the spine Such a force crushes and deforms the body of the involved vertebra The dorsolumbar region is the most frequently affected There may be transient or permanent damage to the spinal cord (From Fourth Edition A M A Primer on Fractures)

CHAPTER 25

INFECTIOUS DISEASES OF THE VERTEBRA

Infectious diseases which may attack the various structures of the back are tuberculosis, syphilis, osteomyelitis, blastomycosis, actinomycosis, brucellosis and oidiomycosis.

BACTERIOLOGY AND CHEMOTHERAPY IN SPINE DISEASES

Chemotherapy is a valuable adjunct in the treatment of localized infections. The intelligent use of chemotherapy requires a knowledge of the nature of the invading agent. This is determined by isolating the organism from the lesion.

Tuberculosis is still a very common cause of localized infections. The instances of tuberculosis which have been seen in the past five years at the Mayo Clinic have almost entirely been caused by the human type of Mycobacterium tuberculosis, whether the lesions have been in bone, lymph nodes or skin.

In Weed's experience tubercle bacilli have been encountered more frequently than all other organisms combined. However, infections with other organisms, and especially the fungi or species of Brucella, often give rise to chronic conditions in bones, joints, tendons, bursa or subcutaneous areas. These conditions may closely simulate tuberculosis by the their clinical course, by roentgenologic appearance or by histopathologic study. The tuberculin test is of little help in establishing a positive diagnosis.

The choice of the antibiotic agent for a given patient should be based, at first, on the effectiveness of the various antibiotics against the general type of bacterium causing the infection and, later, on the susceptibility of the infecting bacterium to the various antibiotic agents as determined by *in vitro* sensitivity test. In this way, according to Altemeier and Largen, a mistaken choice can be corrected within twenty-four to forty-eight hours on the basis of sensitivity tests. This procedure is preferable to the blind selection and haphazard trial of antibacterial agents. In general, only one or possibly two antibiotic agents should be used. Shotgun mixtures should be avoided. The antibiotic agents, especially penicillin, are generally preferred. Bacteriological studies and sensitivity tests are especially important in chronic lesions. Erythromycin or ilotycin is most active against gram-positive microorganisms, especially the hemolytic streptococcus, the pneumococcus, and penicillin-resistant staphylococci. It is readily absorbed into the serum when administered by the oral route and diffuses readily and uniformly into most of the body tissues. Its antibacterial activity and its lack of serious toxicity make it highly desirable. Its spectrum of activity is similar in many respects to that of penicillin.

roentgen-ray appearances and treatment apply here as in uncomplicated fractures The prognosis, however, is always more grave

A dislocation or fracture-dislocation of thoracic or lumbar vertebræ should be treated by slow steady traction and countertraction Resistant cases require manipulation under anesthesia and in some cases open operation

There are many cases of fracture-dislocation with or without spinal cord injury where manipulation accomplishes excellent reposition of bones which is followed by complete relief There are other cases where manipulation or open reduction may cause grave damage to an unharmed cord

There is a possibility of injuring the spinal cord by closed manipulative reduction in cases of fracture-dislocation of the cervical vertebræ Traction to the head, chin, and occiput, with sand bag supports on either side of the head, should be employed When reduction is satisfactory and sufficient stability has occurred, a plaster cast should be applied

In fracture-dislocations of the thoracic and lumbar vertebræ, reduction should be followed by firm fixation in a plaster cast before traction is removed For complete and permanent relief, fusion of the affected area is advisable

Hibbs strongly advised fusion operation, claiming that elimination of movement is essential to complete and permanent relief In every case where his operative technic was employed, complete relief followed The fusion included at least one unaffected vertebra above and below the injured vertebra The patients were kept in bed for eight weeks and were required to wear a support for two or four months longer The support in each case was of the Taylor spine brace model except in lumbar cases when it was shortened above to extend only to the tips of the scapula and lengthened below to grasp the pelvis

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Combined Antibiotic Therapy.—Although the intelligent combination of antibiotic agents is highly useful and desirable, there are certain pitfalls if it is done without regard for the phenomenon of interference (Herrell). It is unwise to combine penicillin with aureomycin, whereas either penicillin or aureomycin may be combined with streptomycin to a considerable advantage. Dihydrostreptomycin is an exceedingly important antibiotic.

The strains of certain organisms which are made resistant to terramycin develop increased resistance to aureomycin and chloramphenicol. On the other hand, these strains are not made resistant to streptomycin and at times may develop increased sensitivity to it.

The haphazard use of combinations of antibiotics or shifting rapidly from one to another is to be condemned. It is only by careful bacteriologic studies, including sensitivity tests, that one can treat bacterial infections intelligently.

TUBERCULOSIS OF THE VERTEBRÆ (POTT'S DISEASE)

Tuberculosis of the spine comprises over 50 per cent of all the bone and joint manifestations of this disease.

Tuberculosis may involve any vertebra but attacks the thoracic and lumbar segments most commonly. The name of Percival Pott is associated with this disease.

Human vertebral tuberculosis may be due to infection by the human, bovine or avian organisms. The tubercle bacilli enter the blood stream from foci elsewhere in the body, usually the peribronchial or retroperitoneal lymph nodes. They have a predilection for the bodies of the lower thoracic and upper lumbar vertebræ. The usual route of transmission is through the blood stream, but it may be by way of the lymphatic system.

Cleveland believes the body of the vertebra which has an adequate blood supply is invaded directly. The intervertebral disk which is without a blood supply is involved secondarily. Destruction of an intervertebral disk means advanced disease of the adjacent vertebral bodies.

Etiological Factors.—The disease usually starts in early childhood, during adolescence or in early adult life. In the later period some of the newly developing lesions probably result from the exacerbation of latent foci established months or years before. The original portal of entry is difficult to determine at the stage of the disease when a spinal lesion makes itself known. The appearance of calcified lymph nodes may be a clue to the original portal of entry. It is possible that tubercle bacilli reach the vertebræ from the overlying thoracic duct and its related lymphatic channels.

The preponderance of Negro victims is especially striking.

General Adaption Syndrome in Tuberculous Infection.—Matteucci describes Selye's concept of the general adaptation syndrome. Tuberculous infection is a manifestation of the organism's reaction to the presence of Mycobacterium tuberculosis. In its first contact with the organism, the bacterium causes a specific stimulus to which the organism reacts by forming antibodies, and a nonspecific stimulus, the "stressor," to which the organism reacts with the hormonal mechanism described by Selye. The anterior hypophysis secretes ACTH that stimulates adrenocortical produc-

tion of mineralocorticoids and glucocorticoids. In primary tuberculous infection in a child, all three stages of the general adaptation syndrome may be seen. The pre-allergic phase characterized by negative reactions to tuberculin tests represents the alarm reaction period.

A stage of resistance follows during which adaptation reaches its maximum. In some individuals despite prolonged resistance Mycobacterium tuberculosis does not find an adequate opposition and the stage of exhaustion occurs. Sometimes the first tuberculous infection is followed by primary tuberculous bronchopneumonia, primary caseous pneumonia, or extrapulmonary dissemination through the blood. The phase of resistance lasts as long as the anterior hypophysis secretes corticotropin in quantities sufficient to stimulate *and maintain adrenal cortex production of mineralocorticoids* and glucocorticoids in optimal proportion. The mineralocorticoids have a stimulating effect on tissues, cause exudative or allergic reactions, and stimulate liberation of histamine that enhances the virulence of Mycobacterium tuberculosis. The lung contains more histamine than any other organ. If the bacterium is present when the action of mineralocorticoids is not balanced by the histamine-inhibiting action of glucocorticoids, its virulence is greatly increased, and allergic or exudative phenomena are manifested.

Two anatomical types of vertebral tuberculosis may be recognized early, the central involvement of the body of the vertebra, and invasion of the anterior portion of the body with early bone destruction. The third type is called epiphyseal tuberculosis of the vertebra because it affects the epiphyseal area of the body. The anterior type begins in or near the anterior cortex of the body and spreads up and down the spine beneath the anterior spinal ligament to invade and erode the anterior portions of the bodies of adjacent vertebrae without causing much damage to intervertebral disks or collapse of any vertebral body until late in the disease.

Doub and Badgley distinguish the central articular and the anterior types of vertebral tuberculosis. The central type causes collapse of the body of the vertebra in a high percentage of cases, while in the anterior vertebral type the body is preserved until late in the disease.

Cleveland and Bosworth claim that since the main intervertebral joint is without a capsule or synovial lining and has no blood vessels, the ordinary method of implantation of tubercle infection, as an embolic process, cannot apply to the intervertebral disk. The lesion must, therefore, begin in the bone or in the surrounding soft tissue which has an adequate blood supply. The disease may begin in the diarthrodial joints posteriorly, but this is not seen often.

They examined numerous specimens of the human spine which had been invaded by tuberculosis, and found two constantly recurring gross pathological states in the bone: first, caseation of bone and soft tissue—a destructive lesion due directly to the infection, and, second, sclerosis of bone, which is a vascular phenomenon occasioned by loss of blood supply from thrombosis or endarteritis, occlusion or destruction of blood vessels by the presence of large dissecting abscesses.

Tuberculous osteitis destroys the framework of the vertebrae. Westermark and Forssman distinguished a granulating fungous form, which resorbs

the bony framework, and a caseous form, which brings about necrosis of the lamellae Tuberculous spondylitis can be divided into focal and diffuse osteitis Focal osteitis is more common in adults, while the diffuse type is more frequent in children One type of focal spondylitis is limited at an early stage by osteosclerosis and periosteal deposits, another is characterized by a rounded or irregular sequestrum and a rarefied border zone Focal spondylitis is most often localized to the anterior lateral border of the vertebral body It can be diagnosed roentgenologically before the destructive process has produced compression and a gibbus On the other hand, diffuse spondylitis is not recognized roentgenologically until there is compression with gibbus formation The destruction rapidly infiltrates the greater part of the vertebral body, usually in its anterior portion Compression makes the vertebra wedge-shaped

Gross Appearance —The appearance of the bone may assume two distinct forms productive (sclerotic) or exudative (caseous, destructive)

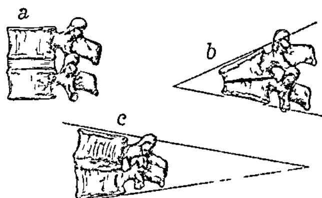


FIG 141 —(a) Shows normal vertebræ (b) relation of vertebræ in tuberculosis with weight borne on anterior portions (c) object of hyperextension with weight borne on posterior portions (Lewin courtesy of Am Jour Dis Child)

Productive Form —In all stages the bone assumes a yellow color These yellow areas gradually extend toward the posterior aspect and the intervertebral disk The bone is firm and maintains its morphological integrity though the entire vertebral body be involved The intervertebral disks are intact

Exudative Form —In the exudative type the bone assumes a yellow color Soft areas of liquefaction of varying size develop within the yellow areas the liquefied areas consisting of soft gelatinous material and frequently bone fragments With progression of the liquefying process, usually with extension into the intervertebral disk compression of the vertebra by the body weight occurs and a gibbus results Sequestration of bone may be produced by a caseous process

In the productive form granulation tissue rich in capillaries fills the marrow spaces This may erode but never completely destroy the bone trabeculae With it there may or may not be areas of caseation

In the exudative type the general appearance is that of large areas of caseation which have completely destroyed all normal bone architecture The roentgenographic appearance of the exudative form when the vertebral

body is collapsed and the disk destroyed, permits the roentgenologist to detect the destructive process.

Auerbach and Stemmerman noted that not a single correct diagnosis was made in 25 per cent of those cases where the lesion was productive.

An abscess was diagnosed correctly ten months before death, but repeated complete spine roentgenograms failed to reveal involvement of a single vertebral body. At necropsy every vertebra was diseased, some only partially, but the majority completely. Yet the intervertebral disks were intact and microscopic study of the bone revealed the trabeculae to be eroded but not destroyed, the caseation in the marrow spaces being more or less walled off by the productive elements. Obviously with the trabeculae intact there could be no collapse of the vertebra or demonstration of areas of lessened density on the roentgenograms.

Under these roentgenologically ideal conditions, one change persists—areas of increased density corresponding exactly to the diseased areas noted grossly. These changes are called "sclerotic." Productive and exudative disease may co-exist in different vertebrae of the same column. It is important for the roentgenologist, even when a destructive lesion is demonstrable, to examine the entire spine carefully for evidence of "sclerotic" changes.

Lavalle formulated the theory that in all tuberculous lesions there is, in addition to the caseous area, a nearby focus called a nucleus, which is a sort of stop-gap repository of beneficial material which if released by perforation liberates certain substances which have a salutary effect.

From his studies on **"The correlation of pathologic and roentgenologic findings in tuberculosis and pyogenic infections"** Phemister has shown that the contacting hyaline cartilages of joints resist destruction more effectively from tuberculosis than from pyogenic infections. In their studies of the pathological changes in the spine, Compere and Garrison found evidence that the intervertebral disk and the cartilage of the knee or the hip joint react to infections similarly. Tuberculosis of a vertebra usually arises from a blood-borne transplant from a lesion of the lung or alimentary tract to the spongiosa or compacta of the body. Tuberculosis of the spine commonly begins as a metaphyseal focus with the vertebral appendages rarely involved. It is primarily a bone-destroying infection. In the active stages of the disease there is little evidence of bone repair. The intervertebral disk resists tuberculous infection.

Pyogenic infection is frequently primary in the arch or vertebral appendages. Early and complete destruction of the intervertebral disks is common. In contrast with tuberculosis of the spine, bone regeneration and fusion of vertebral bodies may be pronounced. This rapid destruction of the intervertebral disk is accomplished by the proteolytic enzymes produced by the polymorphonuclear leukocytes in pyogenic exudates.

The abscess in tuberculosis of the spine spreads by extension under the anterior longitudinal ligaments with invasion of the anterior borders of the vertebral bodies. The annulus fibrosus of those intervertebral disks that are in direct contact with the tuberculous abscesses shows relatively little absorption, whereas it is promptly destroyed by pyogenic exudate. Pyogenic infection may spread by direct extension through or around an intervertebral disk from one vertebral body to another.

The epiphyseal or intervertebral articular type of disease begins in or near the upper or lower surface of the body, spreads to the intervertebral disk and through the nucleus pulposus to the adjacent vertebra. From pathological studies Compere and Garrison concluded that the intervertebral disk is highly resistant to destruction by tuberculous granulation tissue. This may be true for children, but the observations of Doub and Badgley indicate that it is not true for adults. These authors believe that in the intervertebral articular type the process begins along the articular margin where the disk is attached. The normally poor circulation of the disk is soon destroyed with early disappearance of the disk and approximation of the vertebræ.

Limitation of movement is due to pain, muscle rigidity and pathologic changes within the joint.

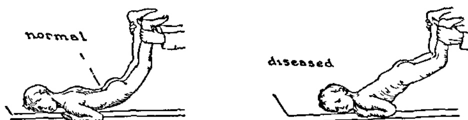


FIG 142.—Method of demonstrating rigidity of the spine in vertebral tuberculosis. (Babcock's Textbook of Surgery.)

Signs and Symptoms of Tuberculosis of the Vertebræ

Limitation of movement
Muscle spasm
Limp if psoas abscess is present
Pain
Night cries
Atrophy of bone and muscle: disuse, neurotropic
Deformity due to: bone destruction
contracture of soft tissues
contraction of soft tissues
Tenderness and sensitiveness
Roentgenography: A. haziness or clouding of joint space
B. narrowing of joint space
C. bone atrophy
D. bone destruction
General symptoms: weakness, malaise, anorexia, anemia, afternoon fever
Blood examination—routine—complement fixation
Tuberculin tests
Aspiration: tubercle bacilli in abscess
Biopsy test: excision of bone, cartilage and synovia for microscopy
Guinea pig inoculation test:
A. injection of pus
B. implantation of synovia, bone or cartilage and reproduction of tuberculosis in a guinea pig

Muscle spasm is a protective phenomenon on the part of the neighboring muscles to hold the bones at rest

Pain may be local or referred

Night cries occur in children usually before midnight They are due to the relaxation of the muscles during sleep, permitting movement of the joint which causes pain

Atrophy of bone and muscle is characteristic and is due to disuse and disturbance of the normal nerve supply i e, neurotrophic

Deformity is due to bone destruction contraction and contracture of soft tissues such as muscle tendon fascia and joint capsule

Tenderness to touch and sensitiveness to movement are constant

Signs, Symptoms, Physical Findings — The signs, symptoms and physical findings of vertebral tuberculosis are limitation of movement, muscle spasm, a characteristic protective attitude, pain, night cries of children deformity, tenderness, sensitiveness, abscess formation a limp in certain cases and roentgen-ray changes Tuberculosis usually produces a kyphosis In the cervical and lumbar regions it causes a diminution of the normal lordosis Flexion of the back is limited and painful, and extension tends to relieve the discomfort The most important finding is muscle spasm It is always present The muscle defense exerts a protecting immobilizing influence

The symptoms are caused by an inflammatory process, interfering with the function of a weight-bearing or movable joint, and the absorption of toxins

Muscular Spasm —Muscular spasm is Nature's attempt to put at rest inflamed tissue The sensory nerves having been irritated by the inflammatory process, cause this involuntary muscular contraction

Limitation of Motion —Limitation of motion the result of muscular spasm aroused by the sensory impulse is practically constant

Pain —Pain is nearly always present and localized to the region of disease due to the pressure from bearing weight It may also be referred through the nerves which lead through or are directly adjacent to the zone of inflammation as for example in the upper spine through the intercostal nerves Absence of pain should not mislead the examiner

Night Cries —Night cries are the result of pain occurring when sleep allows relaxation of muscles to occur Any slight movement may thus produce sensory nerve irritation

Tenderness to pressure and sensitiveness on slight movement are almost always found Where the exudative process extends into the overlying tissue palpation may reveal a boggy feeling Swelling in this area may also be noticed

Posture —Typical attitudes are found in some types of tuberculosis of the spine When the disease involves the cervical region of a child he rests his chin in his hands as though bracing his head and neck Supporting the chin by elevating it with the palms of the hands produces extension and relief in tuberculosis of the cervical spine When the thoracic vertebrae are affected there may be a grunting sound during breathing The most important symptom is stiffness of the back In tuberculosis of the thoracic region the military attitude is commonly seen The weight in this attitude

The epiphyseal or intervertebral articular type of disease begins in or near the upper or lower surface of the body, spreads to the intervertebral disk and through the nucleus pulposus to the adjacent vertebra From pathological studies Compere and Garrison concluded that the intervertebral disk is highly resistant to destruction by tuberculous granulation tissue This may be true for children, but the observations of Doub and Badgley indicate that it is not true for adults These authors believe that in the intervertebral articular type the process begins along the articular margin where the disk is attached The normally poor circulation of the disk is soon destroyed with early disappearance of the disk and approximation of the vertebræ

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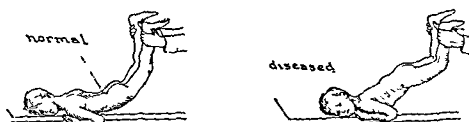


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afternoon fever
Blood examination —routine—complement fixation
Tuberculin tests
Aspiration tubercle bacilli in abscess
Biopsy test excision of bone cartilage and synovia for microscopy
Guinea pig inoculation test
A injection of pus
B implantation of synovia bone or cartilage and reproduction of tuberculosis in a guinea pig

Ornstein and Ulmar, were amazed at the extensive tuberculous destruction of vertebral bodies that can exist without symptoms or signs of tuberculosis of the spine and without roentgen evidence of disease

One of the first roentgen signs of tuberculosis of the spine is narrowing of an intervertebral disk which may become marked before there are noticeable changes in the vertebrae Irregular narrowing of the disk and subchondral bone destruction are among the earliest and most constant roentgen findings The bone destruction usually appears in the anterior portion of the vertebral body and upon its narrowing, compression or collapse produces the wedge shape so characteristic in the lateral roentgen

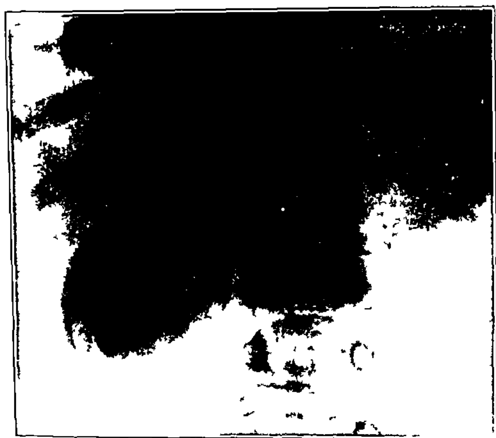


Fig 143 —Vertebral tuberculosis calcified psoas abscess due to tuberculosis of 12th thoracic and 1st and 2d lumbar vertebræ

projection A valuable sign when present is lack of parallelism in the opposing vertebral borders

Cleveland and Bosworth believe there are certain roentgenographic findings previously overlooked such as sclerosis or mottling of the vertebral bodies, which lead to an earlier diagnosis of the disease than was formerly possible

The characteristic picture of the late stage is the destruction and collapse of the bodies anteriorly with obliteration of the disks and a consequent kyphosis

Any paravertebral shadow in the roentgenogram, even without a definite bone lesion should be considered a tuberculous abscess until proved other-

is transferred from the anterior portions of the bodies of the vertebræ to the posterior less affected portions Tiptoe walking to avoid jarring the spine is also seen frequently

Limp—Limp is usually due to irritation of an ilio-psoas muscle

Deformity—Deformity results from the destruction of bone and the contraction of the surrounding soft tissues, with contractures of tendons and muscles, fasciæ and joint capsules

Temperature—Increased local temperature may be discernible

Constitutional Symptoms are due to the toxemia, and are usually manifested by malaise, anorexia weakness and an afternoon rise in temperature

Blood—The hematological examination usually reveals a secondary anemia with a leukopenia and a relative lymphocytosis With a secondary infection, an increase in the white blood cells may be found

Complications—The complications of Pott's disease especially those demonstrable roentgenographically assume added significance when they furnish the only evidence of tuberculous involvement of the spine

The 'cold abscess' is a part of Pott's disease rather than a complication Ninety-six per cent of Auerbach and Stemmerman's patients were found to have cold abscesses at necropsy The complications are (1) abscess, which if opened or allowed to rupture is prone to result in a sinus which may be resistant to treatment (2) Secondary infection (3) Amyloidosis of the spleen liver and kidneys especially after long continued suppuration (4) Metastasis to other joints may occur (5) Tuberculous meningitis is always serious Other tuberculous foci may appear in the mediastinal, retroperitoneal and cervical nodes and in the testes, the lungs and kidneys

In cervical tuberculosis a retropharyngeal abscess may be mistaken for a peritonsillar abscess When the disease affects the upper thoracic region the abscess may be mediastinal

In disease of the lower thoracic and upper lumbar regions a psoas abscess may develop When the lumbar region is affected there may be a 'dumb-bell' abscess—two abscesses connected by a narrow isthmus

Abscess was found by Doub and Badgely at some stage of the disease in 84 per cent of the cases in their series Skipped infection, or two areas of destruction with normal vertebræ between was found in 10 per cent of the cases Concomitant tuberculosis in other parts of the body was found in 53 instances A pulmonary lesion was present in 24 cases

Urinary Complications—In every patient with bone or joint tuberculosis it is necessary to make a systematic examination of the urinary system Colombani found that in a total of 1 328 patients having bone and joint tuberculosis 224 or 16 87 per cent had some disease of the urinary system

Roentgen ray Findings—Roentgenograms of the spine do not always show the full extent of the disease for infiltrated bodies may be present without any narrowing of the disks or other roentgen evidence The first bone changes may be minute localized erosions or even a slight blurring of the sharp contour of the body Either alone or combined with these changes may be found varying degrees of condensation of bone with loss of the trabecular markings

these, 100 had had roentgenographic studies made of the spine, usually less than six months before death

An abscess can be demonstrated in 20 per cent of the cases by x ray or physical examination while at autopsy, abscess has been found in 80 per cent of the cases The extent of this abscess gives a clue to the number of vertebral bodies that are involved

Paraplegia —The cause of paraplegia is pressure by the tuberculous exudate and encroachment on the spinal cord The diagnosis is easily made It is described elsewhere

Compression of the spinal cord is reported to occur in from 6 to fourteen per cent of cases

Diagnosis

While tuberculosis is on the decrease and is encountered less frequently than in former years Ghormley believes one should always bear in mind the possibility of a tuberculous joint

The diagnosis of vertebral tuberculosis is based upon the history, physical examination and roentgen ray studies

The history includes heredity, family, symptoms and signs as related by the patient parent or guardian The chief aid in diagnosis is the physical examination which must be gentle complete and in sequence The interpretation of normal and abnormal responses must be accurate

The roentgen-ray studies may be of negative and positive assistance The roentgenograms are usually negative in the early stages, although later there is usually a fairly characteristic picture of marginal destruction thinning of the joint spaces and diminished density of the adjacent bone

The diagnosis may be suspicious, presumptively positive or absolutely positive

Direct diagnosis is based on symptoms and signs outlined

The only positive diagnosis is made as follows

1 By finding the tubercle bacilli in the aspirated fluid or pus

2 By injecting the fluid or pus into a guinea pig producing tuberculosis and proving it microscopically

3 By finding tubercle bacilli in the synovia cartilage or bone

4 By transplanting into a guinea pig synovia, cartilage or bone tissue, producing tuberculosis and proving it microscopically

Laboratory Diagnosis of Tuberculosis —According to Milzer and Levine acid fast saprophytic bacilli resembling the tubercle bacilli morphologically are being found with increasing frequency in sputum and other specimens submitted for microscopic examination Perhaps the widespread use of antibiotics is partially responsible A laboratory diagnosis of tuberculosis should not be made without positive culture or guinea-pig inoculation The finding of acid fast bacilli in the sputum of patients with negative clinical and x-ray findings is not diagnostic and a culture or guinea pig inoculation should be requested

Isolation of the Tubercle Bacillus —Reitter and Lowenstein have isolated tubercle bacilli from the blood stream by means of a special culture medium

wise Ghormley and Bradley described fusiform, pyramidal and globular forms of abscesses Calcification in an abscess generally is a sign of quiescence of the disease and indicates healing A decrease in the size or early absorption of an abscess is a favorable sign

McBurney considers a narrowed intervertebral space, as seen in a lateral x-ray projection to be the most valuable evidence, in early doubtful cases After a period of time, actual destruction of the body appears in the x ray and may completely destroy the body and spread to adjacent vertebræ The bone involvement usually appears first in the epiphyseal area

Later stages of the disease are shown by progressive destruction of the body, formation of abscess and final deformities of the vertebra depending on the portion of the body which tends to collapse As x-rays are followed the lack of regeneration or reconstruction is noticeable

This is a differential point between tuberculosis and syphilis and other infectious diseases Osteomyelitis is known by its rapid and acute destruction and rapid reconstructive process with new bone formation Although tuberculosis is a lytic lesion many x rays show sclerosis This is explained by Bosworth and Cleveland as an aseptic necrosis due to massive loss of blood supply

Retroposition of Vertebræ as an Early Sign of Tuberculous Spondylitis —Habelstam emphasizes the fact that instability between the vertebræ in the lumbar spine arises at an early stage in cases of tuberculous spondylitis as well as in disk degeneration In the roentgenogram this instability might be revealed as a retroposition which might appear before any tuberculous changes in the vertebra itself are visible

A narrowed intervertebral space is often the first roentgenographic sign of tuberculous spondylitis

Retroposition or backward displacement of vertebræ has been observed only in the lumbar spine Smith found that the most important single factor in determining a posterior displacement was the structure of the lateral articulations between the fifth lumbar and first sacral vertebræ He maintains that if the plane of these joints is more frontal than usual a backwards displacement of the fifth lumbar vertebra is possible

Retroposition has proved to be a sign of degenerative changes of the intervertebral disks in the lumbar spine

Knutsson showed that signs of instability of the lumbar spine in the form of parallel displacement and abnormal tilting movements ' between the vertebræ often occur in case of degeneration of the intervertebral disks

Habelstam observed in 5 cases a backward displacement of one or more vertebræ before the tuberculous vertebræ had collapsed

The classical roentgenographic appearance of Pott s disease (narrowing of the intervertebral disk collapse of the vertebral bodies with or without the shadow of a cold abscess) presents a specific and accurate picture of the actual pathology

The roentgenogram frequently underestimates the number of vertebræ involved and often fails to visualize an extensive involvement

The necropsy examination of 1 545 tuberculous patients at Sea View Hospital disclosed the presence of Pott s disease in 9 per cent of cases Of

Prognosis — The prognosis in a case of tuberculosis of the spine depends on the patient's resistance, the virulence and number of the infecting organisms, the elapsed time and the treatment. The prognosis is good if the general condition of the patient is good. It is favored by the early application of proper treatment, which should be carried out in an institution. It requires good nursing and medical attention.

Sir Robert Jones taught that the older the patient the more nearly the disease approaches malignancy and the more radically it must be treated.

A sinus is a danger because it is difficult to avoid secondary infection. Fusion offers success except in those too old, too ill and too obstinately septic; fusion is contraindicated in the very young. Many patients die of tuberculosis within a few years of being cured of a tuberculous bone. Healing by solid bony fusion in the diseased area requires a long period. The disappearance or calcification of an abscess is a favorable sign.

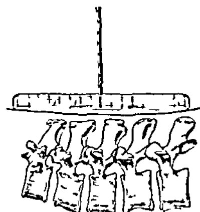


Fig. 144

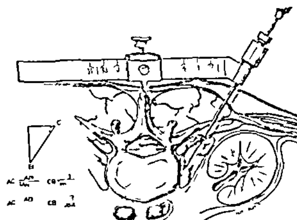


Fig. 145

Fig. 144. Diagrammatic representation of the lateral roentgenogram of the lumbar spine with the metal ruler in place.

Fig. 145.—Diagrammatic representation of the method used for calculation of the distance from the mid line to the point for insertion of the needle. (Ray; courtesy of J. Bone and Joint Surg.)

Complete fusion of the bones produces an internal splint and is a most important aid in healing the lesion. No strain should be put on the back until healing is complete.

I never operate on debilitated patients. I wait until the general condition has improved. In children with tuberculosis of the spine solid bony fusion will often result, in two or three years, without operation.

The marked reduction in the incidence of bone and joint tuberculosis has been due to various public-health measures, such as clean-milk supply, eradication of tuberculous cattle from herds, and the control of the spread of tuberculosis by early recognition and isolation of infected persons.

Streptomycin alone is not as effective as streptomycin combined with standard surgical procedures. The development of resistance to streptomycin by the organisms is retarded by the use of para-aminosalicylic acid.

Tuberculosis of the skeletal system is no longer the dreaded disease it used to be. The process of healing has been accelerated by treatment with

Recent evidence indicates that the tubercle bacillus can be isolated from sternal marrow puncture of acute cases

Petragnani or Lowenstein-Jensen grow cultures in four to six weeks A guinea pig may show positive growths in six to eight weeks If a guinea pig survives three months, it is killed and examined bacteriologically and microscopically

Tuberculin tests have been employed principally for detecting tuberculous infection in early childhood A positive reaction has its chief value during infancy A positive Pirquet reaction means that at some time the person has been infected with tuberculosis, but gives no indication whether the lesion with which one is dealing, is tuberculous Smith believes that the factors of error are an overwhelming tuberculous infection or an acute illness, both of which may prevent or suppress the reaction Errors in technic may be disastrous Smith finds that the intradermal (Mantoux) test is twice as accurate as the epidermal (Pirquet) test

Sedimentation Test—The sedimentation rate is nearly always elevated especially in the initial phase, the range being from 30 to 60 Huet examined the blood in 75 cases of surgical tuberculosis by the sedimentation test and the types of white blood cells In all the cases with large progressing abscesses or the breaking down of tissues with profuse suppuration he found marked acceleration of the sedimentation time, a pronounced leukocytosis and a distinct shift to the left in the white cells

Serodiagnostic Test—Meinicke's serodiagnostic test for tuberculosis is similar to his test for syphilis In a series of 205 cases Verdina obtained negative reactions only in healthy persons In persons known to be tuberculous he obtained 85 per cent of positive reactions This test is not generally accepted

Tuberculosis Cultures and Animal Inoculations—Cohen found as high as 50 per cent of cultures can be negative when patients are under chemotherapy

Differential Diagnosis—The differential diagnosis of vertebral tuberculosis concerns many conditions, including arthritis an injury a disk lesion osteomyelitis, a neoplasm, a visceral lesion, a postural disturbance, an unusual infection and a host of others

Formerly when a patient presented himself with a back condition the diagnostician asked himself the all-important question Is it tuberculosis or not? This is no longer true

Valls and Robertson independently have made valuable contributions to the differential diagnosis of vertebral lesions by means of aspiration biopsy procedures

Needle Biopsy of the Lumbar Vertebral Bodies—Ray described a simple modification of the Valls technic of biopsy of the lumbar vertebral bodies which allows the accurate placement of the needle (Fig 145)

Ray performed forty-eight needle biopsies of the lumbar vertebral bodies and established positive diagnoses in twenty cases tuberculosis six metastatic carcinoma four Ewing's sarcoma one multiple myeloma one syphilis one, nonspecific inflammatory reaction seven negative biopsies twenty-eight

subperiosteal lesions were present in 19 patients (2.1 per cent), and the neural arch was the site of the primary infection in 4 patients (0.5 per cent). Healing of the spine by spontaneous bony fusion of the affected vertebral bodies occurred in 184 patients (27.3 per cent) and apparently sound fibrous fusion occurred in 489 patients (72.7 per cent). Of the 184 patients, 27 (14.6 per cent) required further hospital treatment: 5 because of reactivation of the disease, 7 because of persistent infection in the sinuses, 2 with paraplegia, 3 with a new focus in the spine and 10 because of extraspinal foci. Of the 489 patients 110 (22.5 per cent) required further treatment: 47 because of reactivation, 12 with persistent sinuses, 15 with increasing deformity, 8 with paraplegia, 5 with new foci in the spine and 23 with extraspinal foci.

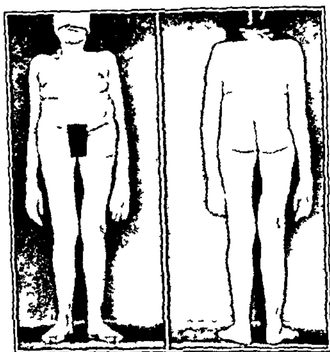


Fig. 146. — Old arrested case of tuberculosis of 8th, 9th, 10th, 11th, 12th thoracic and 1st and 2d lumbar vertebræ.

Healing of the spine does not prevent the development of complications of other foci in the spine or of foci in other joints or in the kidney or lungs. Efforts at healing should include building up the general condition as well as healing of the local focus.

If a kyphos has developed due to the collapse of vertebral bodies, it is not wise to try to correct the deformity by quickly forcing the collapsed vertebræ apart. Prevention of the collapse is warranted and should be attempted, but an empty space should not be produced in the anterior column. If the patient shows normal return to a tolerance of normal physical activities and the disappearance of symptoms, the disease may be considered as arrested. Complete fusion of the laminæ produces an internal splint and is a most important aid in healing the lesion. Fused areas will bend in some cases. No strain should be put on the vertebræ until healing

antibiotics and chemotherapeutic agents The disease can be stopped in some cases when the diagnosis is made early

Early signs of tuberculosis of the spinal column are limited back motion paravertebral muscle spasm and percussion tenderness over the site of the lesion As the process advances, a gibbus may appear, when the vertebral bodies collapse and the interspaces become destroyed A paravertebral abscess usually develops early When it involves the lumbar part of the spinal column psoas spasm will be present Flexion contractures of the hips are common at this stage If allowed to progress sinuses in the back groin or thigh may appear

The early roentgenograms are not diagnostic though any destructive lesion involving the vertebral plate and the intervertebral disk especially in their anterior portion should make one suspect tuberculosis The presence of a fusiform paravertebral shadow enhances this suspicion

In trying to establish a positive bacteriologic diagnosis in suspected cases the temperature chart leukocyte count sedimentation rate and tuberculin tests should not be neglected but the technic of needle biopsy and aspiration and even incision for biopsy has been developed to the point at which positive proof can be obtained

As soon as the diagnosis is established treatment should be begun Treatment with antibiotics and chemotherapeutic agents has aided the old treatment with general measures to increase resistance rest and immobilization Immobilization is accomplished by rest in bed and early spinal fusion The drugs hasten the arrest of the active tuberculous process The lesion is considered quiescent when the involved vertebral bodies are solidly fused

In advanced cases compression of the spinal cord and nerve root may occur from pressure of the abscess or the angular deformity With the protection of the drugs dispelling to a degree the fear of meningitis and persistent draining sinuses radical surgical drainage and debridement are being done The approach in the thoracic region is by costotransversectomy and in the lumbar region by a retroperitoneal renal type of incision

Dobson reported a large series of tuberculosis of the spine 914 patients who were treated almost entirely by conservative measures The cervical spine was involved in 3 5 per cent the thoracic spine in 43 1 per cent the lumbar spine in 32 9 per cent the thoraco-lumbar spine in 16 7 per cent and the lumbosacral articulation in 3 8 per cent Of the 914 patients 171 died a mortality rate of 18 7 per cent Chronic secondary infection was present in abscesses and sinuses in 508 patients and 97 (19 1 per cent) of them died Of 165 patients with paraplegia 24 8 per cent died To determine late results three years after discharge from hospital the working capacity of 390 patients was ascertained 86 per cent had full working capacity 5 8 per cent had partial capacity and 8 2 per cent could not work The ill effect of complications on the prognosis is emphasized particularly in cases of multiple foci of active tuberculosis secondarily infected abscesses and sinuses and paraplegia The incidence of paraplegia was highest in the patients with thoracic disease, occurring in 31 2 per cent of them Early epiphyseal changes were present in 302 patients (33 per cent) the central focus originated in the spongy tissue of the vertebral body in 106 patients (11 6 per cent)

bility of the patient's being ambulatory at an early date, (6) attainment of a permanent healthy roentgenographic appearance of the diseased vertebra. Excellent results were obtained in 72 per cent of the children and 73 per cent of the older patients.

In discussing 301 cases of tuberculosis of the spine, Henderson stated that if an adult patient is in good general condition, and if there is no evidence of impending dissemination of the disease or of draining sinuses that are likely to cause contamination of the operative field, a fusion operation is justifiable.

The fact that tuberculosis of the spine is a secondary focus of a generalized disease, influenced Meyerding's attitude on the treatment of the condition by surgical fusion. His patients frequently showed tuberculous involvement of other organs of the body, especially of the lungs. Abscess formation and spinal cord irritation, with or without sinus formation, have at times complicated the treatment and affected the results.

Results of a study conducted by Swett, Bennett and Street show that the treatment of spinal tuberculosis is not satisfactory because healing occurred in only 35 per cent of the cases studied, while in 45 per cent of these cases healing failed to occur. In general, the operative treatment offered no advantage over the non-operative plan since it was found that healing occurred in 34 per cent of the cases in which operation was performed and in 36 per cent of those in which posterior spinal bridging was omitted. According to these investigators, the dominant factor in the healing of Pott's disease lies in the occurrence, the behavior and the disposal of the abscess. While healing occurred in 35 per cent of the cases, it took place in only 19 per cent of the cases in which a persistent abscess was recorded. The dominance of the abscess is further shown by the finding that in all cases in which an abscess was recorded, the percentage of healing following elimination of the abscess, increased to 59 per cent.

To improve the results of treatment it is essential that there should be better understanding of the nature of an abscess. Until these basic matters are understood, the authors concluded, it is probable that it would not be good surgical practice to undertake early aseptic evacuation of the abscess wherever it may be located.

Kidner and Muro found that the cure of tuberculosis of the vertebra in children depends principally on long-continued rest without weight bearing. They found that patients who have undergone fusion require practically as long and as careful after-treatment as those not operated on.

In minors under eighteen years, according to Mayer, the fusion operation when done during the reparative stage in patients with collapse of three or more vertebrae has a beneficial effect in strengthening a structurally weak spine.

Fusion operation is a means to an end which is absolute internal rest of the diseased area. Farrell believes that cure is frequently attained after fusion operation but practically never after conservative treatment. Steindler requires that the disseminative stage of tuberculosis shall have passed and that the patient shall show unmistakable signs of repair. He finds that fusion operation becomes more and more valuable the more it is restricted to its proper place. The cure of tuberculosis is a problem of the

is complete The fate of the disk varies in different cases, it is destroyed and absorbed in some and survives in others Change in angulation of the kyphos reflects collapse of weakened bone structures as well as altered bone growth due to epiphyseal destruction

Cleveland and Bosworth found that fusion of the spine may arrest the destructive process until the new productive changes have time to heal If there are no areas of living bone to act as centers for "creeping replacement," healing may be prolonged indefinitely or may fail to occur

Cleveland expressed the opinion that surgical intervention offers a chance to rehabilitate patients with serious tuberculous disease in a shorter time than by any other method Spontaneous fusion requires, on an average over six years The mortality from this disease was 26 6 per cent in the 203 consecutive patients in Cleveland's series With adequate operation a high percentage of excellent results and a low mortality may be expected in selected cases

Patients with positive sputum present a definite risk Every effort should be made to control the pulmonary disease before operation is attempted Patients who have definite evidence of metastatic involvement have a mortality of almost 70 per cent, and no surgical treatment, other than emergency measures to relieve pain or abscess, should be attempted

Operation to produce surgical fusion of the spine may be performed without danger of aggravating the disease process It aids in giving stability to the diseased portion of the spine Meyerding found that it does not necessarily prevent extension of the disease formation of abscess, irritation of the spinal cord or paraplegia among patients whose resistance is not good The results of spine fusion are probably better in adults than in children An operation that produces fusion of the entire region of involvement provides better immobilization and consequently better results than does one that effects fusion of a limited region

At the end of five years 396 of Meyerding's 480 patients had been traced of these 396 patients 63 64 per cent had returned to an occupation 7 83 per cent had obtained improvement 3 79 per cent had had temporary improvement with relapse later 6 31 per cent had had no improvement and 18 43 per cent had died

The best results are obtained when patients are carefully selected for operation, when spine fusion is employed during the period of healing of the disease and when such treatment is supplemented by conservative treatment for a prolonged period

The paramount requirements for every patient who has tuberculosis of the spine are rest heliotherapy and a nutritious diet No surgical treatment can be considered a substitute for conservative measures

Spine-fusion operations for tuberculosis of the spine were performed on 817 patients in twenty years at the New York Orthopaedic Dispensary and Hospital Swift reported that 71 per cent of these patients were followed for at least five years of these 61 per cent were followed for from ten to twenty-four years The demonstrable benefits were (1) rest to the diseased area (2) subsidence of the activity of the lesion at an early date (3) maintenance of the kyphos with the minimum amount of deformity (4) growth of the vertebral bodies in the fused area in children, (5) possi-

6 Pressure on nerves
7 Rapidity of spreading with undermining of tissues
8 Exhaustion
9 Amyloidosis

4 Operation for the relief of abscess must include the following
(a) Strict asepsis
(b) Small valve-like incision
(c) Evacuation slowly, because of disturbance of osmotic balance
(d) Irrigation
(e) Tight closure with silkworm gut, unless secondary infection is present, when drainage is instituted

Irrigations may be of some value Heliotherapy and roentgenotherapy are of value Antibiotics and other drugs are the most valuable

Tuberculosis is a general disease Fusion of a joint does not cure the disease One may eradicate the disease locally, but that does not eradicate the disease from the patient as a whole These patients should be given the benefit of heliotherapy before and after fusion operation

It is Ghormley's custom to advise arthrodesis when a diagnosis of tuberculosis has been made positive Prolonged rest rarely produces satisfactory healing The newer chemotherapeutic agents are of great aid

Conservative treatment has its greatest field of usefulness in treatment of children operative treatment has its largest field in the treatment of adults If the adult patient is in good general condition, and there are no draining sinuses, fusion should be produced

Nonoperative Treatment —*Climate* —Authorities differ on the importance of climate, chiefly because of the factors of the patient's purse and the psychological effect Various localities which have received much comment are Leysin, Switzerland, Perrysburg, New York Spring Lake, Ohio, Albuquerque and Sante Fe, New Mexico, Tucson Arizona Colorado Springs Colorado, and the seashore

Heliotherapy —According to Rollier, *heliotherapy* may render surgery unnecessary Although bedridden for months, the patients have as a rule excellent appetites and their blood becomes richer It is surprising to note the excellent physical development and firm musculature of patients who have been in bed for years The sun treatment exercises a remarkable analgesic effect

Colloidal Copper Morrhuate —Amorin reported remarkable improvement in tuberculous abscesses treated by injections of colloidal copper morrhuate

Intravenous Calcium Chloride and Ultraviolet Rays —Chavelin and Sicard inject solutions of calcium chloride intravenously

Diet —Thegel found that calf spleen has a markedly beneficial influence on human tuberculosis by producing antibodies and increasing the resistance of the affected tissue

Operative Treatment —Treatment should always have in mind a permanent cure rather than a compromised result Girdlestone says the part the surgeon plays in the operative treatment of tuberculosis of joints is (1) to remove a metastatic tuberculous focus, (2) to buttress or rebuild a part of the skeleton which cannot otherwise safely carry the strain it will have to bear

general reaction of the organism One should continue to use the fusion operation but he should be very rigid in defining its proper field of application

When one considers the general run of patients surgeons and facilities he is forced to conclude that it has not been proved that operative fixation of the spine hastens elimination of the infection more than adequate conservative methods

Treatment —*Anyone who has treated a person for tuberculosis of the* spine realizes that he must treat an individual who at the moment has a diseased spine It is a general disease with local manifestations

Indications

Arrest the disease process
Preserve normal anatomy
Establish optimal physical and mental health
Immobilize the patient and the affected area
Maintain morale
Relieve abscess if present

Methods of meeting indications

Recumbency
Rest
Special frames
Traction
Extension
Immobilization
Food—vitamins
Optimal health { physical / mental
Ultra violet radiation
Tonics
Support
Aspiration
Operations
Antibiotics and other drugs

Operative Treatment —Operations are performed for one or more of five reasons viz for the relief of abscess for the cure of sinus to eradicate diseased tissue, to correct deformity and to stabilize or immobilize a diseased area

1 Removal of the tuberculous focus if possible
2 Removal of the affected bone is not possible
3 Treatment of the abscess
    (a) Puncture and aspiration which usually must be repeated
    (b) *Injections of various solutions*
    (c) Incision and evacuation
    (d) Indications for opening an abscess are present if there is
        1 Danger of spontaneous rupture and secondary infection
        2 Secondary infection already present
        3 Pain
        4 Large sized abscess
        5 *Interference with mechanical treatment* because of its peculiar location

6 Pressure on nerves
7 Rapidity of spreading with undermining of tissues
8 Exhaustion
9 Amyloidosis

4 Operation for the relief of abscess must include the following
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Patients for operative treatment should be in good general health should be free from active pulmonary disease, and should not have tuberculosis of the genitourinary tract

Albee stated that bony ankylosis is the proper criterion of arrested disease both in adults and in children Brackett also believed that ankylosis was the only result which could be considered as a safe cure of the tuberculous disease which had passed into the destructive stage

Hibbs believed the elimination of motion by fusion operation offered the only means of curing the disease It should be done early in the disease, and may be done as early as the sixth year without disturbance of growth



Fig. 147 Tuberculosis involving two areas of the spine thoracic 12 and lumbar I and lumbars IV and V

Before taking a bone graft from the leg, a tourniquet should be applied to the midthigh region A bone bank has been in operation in Inclan's Clinic for several years Many clinics have established bone banks

Treatment General and Local —One must treat a patient who has a tuberculous spine as well as a tuberculous spine which is part of a patient The treatment consists of immobilization of the patient as well as the back Immobilization includes internal and external splinting Internal splinting means operation

Operative measures are complementary to but do not replace the classical methods of treatment Underlying principles remain the same *The tuberculous infection persists in the vertebræ for months or years*

The two chief basic types of operation on the vertebræ are the Albee tibial graft and the Hibbs spine fusion.

Albee Operation. — Albee uses two methods almost exclusively: the single-graft inlay and the bent shingle or bundle of reeds. The exposure and preparation of the spinal gutter, or graft bed, is the same in all cases. With a broad thin osteotome the spinous processes of the affected vertebræ and of two above and two below are split in halves longitudinally, almost down to the neural arches. Care must be taken to fracture only one-half of each spinous process. The gutter for the graft must be bounded by a row of fractured half-spines on one side and a row of unfractured half-spines on

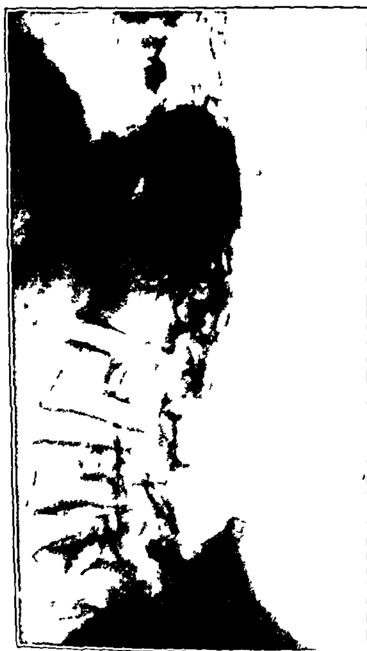


Fig. 148.—End result following spine fusion for tuberculosis of 1st and 2d lumbar vertebræ by the Albee massive tibial graft supplemented by the Delagenière-Lewin procedure.

the other The single graft from the tibia must be long enough to cover the entire length of the gutter, including that made in the intact vertebræ Its diameter should be one-fifth that of the tibia By cutting the upper and lower portions of the graft at an angle to the axis of its middle portion, which crosses the crest, one can secure a graft with a curve This flexible graft is then placed edgewise in the spinal gutter It is secured in position by kangaroo sutures passed through the split supraspinous ligament A thin strip of bone $\frac{3}{4}$ inch long, taken from the side of the gutter in the tibia, is now placed transversely over the tip end of the graft and under the supraspinous or interspinous ligament, in close proximity to the two halves of the spinous process, which are stripped of periosteum and recessed to receive it Having been firmly fixed at one end the graft is now grasped in a clamp, bent into the gutter and held with interrupted sutures of kangaroo tendon while the molding progresses The extreme end is held by another transverse locking graft of bone (This cross-graft prevents the end of the graft from springing out of the gutter)

When the lesion is more extensive, the "bundle-of reeds" technic is employed After the exposure of a sufficient area of the central portion of the antero-mesial surface of the tibia to provide a graft of the requisite length and diameter, longitudinal cuts are made, with the twin saw blades approximately $\frac{1}{2}$ inch apart, down to the marrow With the single blade saw cuts are made between these two down to the marrow, so as to provide four thin strips These intermediate cuts fall somewhat short of the original two, so that when the latter are joined by a transverse cut at each end, the entire graft is lifted out in one piece, with a bridge across each end where the intermediate cuts fell short This "bundle of reeds" is then placed in the gutter and fixed at the midpoint with kangaroo tendon, the individual flexible grafts are then telescoped so as to cover the entire graft bed

Campbell transplanted a portion of the crest of the ilium into the spinous processes, after the manner of Albee The crest of the ilium conforms to the normal lumbar lordosis in this region

Treatment of Tuberculosis of the Spine in Children —Tuberculosis of the spine, in children as well as in adults, should always be treated conservatively at first The general treatment should be combined with absolute recumbency in a plaster bed for a long period

Children with tuberculous spondylitis should be kept in a reclining plaster bed until the tuberculous process is completely checked By a gradually increasing and painless pressure, one should attempt to correct the kyphosis so that a straight tibial graft may be implanted The result of this treatment has been an 80 per cent corrected kyphosis with straight back and excellent function After the operation the patient lies in his plaster bed for several months He is then allowed to be ambulatory with a back support or a brace

Tuberculosis of the vertebræ in children responds favorably to fusion operations Their spines fuse rapidly and the vertebral bodies continue to grow Eighty per cent of good results were obtained in Haas' series of 60 operations By early intervention the cure may be hastened and extension and deformity prevented The operation may be performed at any age but there is a better outlook for good fusion after the age of three

years It is important that sufficient protection be given for at least a year after operation The only height these children lose is that which would have been contributed by the destroyed vertebral segments Cleveland has followed some of these children over twenty years and observed their growth His records show over 70 children under ten years of age, twenty of these under five years, who have been subjected to spine fusion for tuberculosis The mortality rate among the children of ten years of age and younger was only about one-third as high as that for the entire series Surgical fusion saved them years of recumbency in the hospital

In Cleveland's experience, spontaneous fusion in tuberculosis of the spine requires approximately six years If healing can be hastened by surgical intervention to secure fusion of the spine in a matter of six months to a year, the victim of vertebral tuberculosis is saved many years of suffering and uncertainty

Area of Spine Involved—Tuberculosis may invade any vertebra The overwhelming majority of vertebral involvement is in the area of the spine from Th 5 to L5 with the apex at Th11

Technic of Spine Fusion—The technic utilized to secure fusion of a tuberculous spine is of great importance The best and most effective bone grafting material is yielded by thin strips of cancellous bone of the ilium This is readily and rapidly incorporated into the host bone

For these reasons Cleveland prefers to use iliac bone The patient has an abundant supply of bone in his pelvis readily available for grafting At the right and left posterior-superior iliac spine regions and at the right and left anterior iliac crests there is enough bone for four or five spine fusions This autogenous bone has proved to be an adequate bone bank or reservoir

A short spine fusion presents minimal problems To secure fusion of a long area of the spine necessitates some planning with multiple operations There seems to be a definite point beyond which the patient does not tolerate the shock of spinal surgery Any attempt to force a patient beyond a safe margin of surgery may lead to shock from which no resuscitative measures can reclaim him If six or more vertebræ have to be fused surgically the operation should be performed in hemistages right and left Fusion of the spine including twelve or more vertebræ may require up to four or five hemifusions The intervals between these multiple surgical procedures are usually four weeks

The first donor sites are the posterior superior iliac spine areas where large masses of cancellous bone can be obtained in strips of barrel stave type as well as small chips The anterior iliac crests also afford similar bone

Cleveland exposes the area of the spine which is to be fused by a midline incision with subperiosteal dissection of the spinous processes and laminæ unilaterally only if a series of hemispine fusions are planned The interspinous and interlaminar ligaments are removed by curette Vigorous percussion must be avoided to prevent spinal shock In the lumbar spine where there is greater mobility between the vertebræ the articular facets are often partially excised with osteotome and gouge Complete excision should be avoided because of lessened stability Over this denuded area of roughened bone surface the iliac bone is packed interlacing the strips and chips into a continuous mass over which the deep tissues and skin are

closed in layers. During the operative procedure, whole blood is administered in sufficient quantities to compensate for loss by hemorrhage.

For two weeks before spine fusion for tuberculosis streptomycin is given, usually 1 gram a day for adults. After the fusion, the same amount is administered indefinitely. Cleveland keeps the patient in bed for at least one year after operation.

Lewin Fusion Operation.—This operation producing more rapid ankylosis, proposed by me in 1921, is a combination of the fusion operation of Hibbs and the osteoperiosteal graft of Delagenière. The method consists of the classical fusion operation with the technic of Hibbs, and the placing of one or two osteoperiosteal grafts obtained from the tibia by the technic of Delagenière, in a bed of bone that has been denuded of its osteoperiosteal layers. The purpose of the graft is to furnish the elements necessary in the production of new bone, and thereby to effect a more solid early ankylosis. The advantages are: quicker and more complete solidification, and reduction of the danger of pseudoarthrosis. It produces a continuous bony bridge across the posterior portions of the bodies and laminæ (Fig. 148).

The osteoperiosteal graft is taken from the internal surface of the tibia by means of an osteotome and mallet. A long incision is made through the skin over the middle of the internal surface of the tibia without cutting the periosteum. The latter is exposed and the grafts are outlined with a scalpel. Each graft may be removed separately, or one full width graft may be removed and cut longitudinally with heavy scissors. Following the outline the grafts are removed with an osteotome. By varying the inclination of the osteotome one obtains the proper thickness, approximately that of a ten-cent silver coin. When the graft is removed, it is placed in a compress and immediately transplanted into the wound of reception, which has previously been prepared.

Emphasis must be placed on the fact that the operation is one part of the cure, and that the mechanical fixation and treatment are still of paramount importance. I believe that the osteoperiosteal graft, first recommended by Ollier and established firmly by Delagenière, is an efficient bone producer.

Girdlestone considered operation most valuable for adults but definitely a part of conservative treatment. It shortens the period of recumbency and minimizes the need for external splinting, but there is no short-cut to a cure. An adult with tuberculosis of the spine needs long-continued open-air treatment and the greatest care after he goes home. Calvé emphasized this when he said that the patient must lie flat for several hours a day, go to bed early, avoid fatiguing work and sudden movements and wear a splint (external or internal) for life. For children the optimal time for operation is when the disease is quiescent, after years of recumbency, the patients selected are those in whom disease has led to such instability of the spinal column as will through strain cause progressive deformity which is difficult to check by splinting and will be likely to lead to recurrence of the disease. Girdlestone found that "in lumbar and thoracolumbar cases an Albee graft is generally satisfactory, but in mid thoracic and upper thoracic cases a Hibbs operation supplemented by osteoperiosteal grafts (Delagenière-Lewin) is best."

Ito, Tsuchiya and Asami devised a technic for the total dissection of the body of a vertebra. For Pott's disease involving the lumbar vertebra below and including the second, their paraspinal incision with extraperitoneal approach is advantageous, in that, resection of the body is comparatively easy and the danger of contamination of the peritoneum is obviated. For resection of the body of the 12th thoracic or 1st lumbar vertebra an oblique incision similar to that for nephrectomy is executed with the least hemorrhage. A preliminary costotransversectomy enabled these authors to resect the body of a thoracic vertebra.

The value of planography in the radical surgical treatment of 58 cases of spondylitis under a cover of streptomycin was summarized by Orell and Bäcklund as follows:

1. The position and extension of the bone lesions in the vertebral body can be demonstrated more distinctly with planography than with ordinary radiography;

2. The development and the healing of the destructive processes can be determined; and

3. The operation can be planned more accurately than before.

Extensive Spine Fusion.—Cleveland reports that the entire thoracic spine has not infrequently been surgically fused and on occasion the spine fusion has extended continuously from occiput to sacrum. Long segments of the spine have been fused successfully in hemistages with healing of the lesion and restoration of the patient's health.

In fusion of a tuberculous spine Cobey uses the curved Wilson plate. The device is applied over a gibbus or lordotic curve by means of bolts and self-locking nuts. If desired, two plates can be used. Hibbs fusion technic is employed. The dorsal surface of the lamina is elevated, part of each facet is removed and tibial cortex or cancellous iliac bone is set into the facets and across the laminae.

Pseudarthrosis or Failure of Fusion.—Cleveland never assumes that a spine fusion has been technically successful. It must be proved clinically and by roentgenograms that solid bony fusion exists over the area planned. In order to detect failure of fusion these patients are examined frequently. Persisting pain and tenderness over the fused area and lack of improvement in the patient's general condition are suggestive. Roentgenograms in forward and backward and lateral bends are taken at six-month intervals. These must superimpose if the fusion is solid. Any questionable fusion is subjected to exploration and repair of the pseudarthrosis, since one has no assurance that such technical failures will heal the disease. Paraplegia, which occurs in approximately 24 per cent of patients with tuberculosis of the spine, does not recover permanently unless the spine is solidly fused and in some instances, the abscess must be evacuated.

Posterior Tuberculous Sinuses of Vertebral Origin.—Cincotti and his coworkers show that spinal fusion is the most effective method in the control of the vertebral infection, while streptomycin therapy has proved extremely important in the control of the frequently associated infection of the soft tissues. They were concerned with the posterior tuberculous abscess or sinus complicating Pott's disease. In 2 of 7 cases in which wound revision with primary closure was undertaken, recrudescence of an abscess occurred

under the firmly healed wound. When a period of continuous decompression following debridement was allowed before wound closure was undertaken, in only 2 of 26 cases was there recurrence of a sinus in a healed wound. The effectiveness of streptomycin therapy of tuberculous sinuses has been improved by the observation of the following surgical principles: superficial encapsulated tuberculous pus must be drained, the tuberculous sinus must be widely unroofed, tuberculous granulation and fibrous tissue must be removed.

Streptomycin Combined with Surgery in the Treatment of Vertebral Joint Tuberculosis.—Reports on the effect of streptomycin have been very encouraging and stimulating. Brock, Morgan and Bosworth reported success with streptomycin in the treatment of tuberculous sinuses. Bickel and others treated patients with streptomycin, some in conjunction with fusion procedures, with good results. Pulaski and associates treated 24 cases, 18 of the spine and 6 of the extremities, with 6 good results. Michele and Krueger reported success with the use of both streptomycin and surgery. The largest and most carefully studied series of cases with the best results was that reported by Bosworth's group.

The purpose of Smith and I-Sen Yu's study was to determine the effect of streptomycin in conjunction with surgical procedures.

The effect of streptomycin is bacteriostatic. Streptomycin combined with surgical procedures has a striking effect on active tuberculous infections of bones and joints and undoubtedly makes it possible to perform operative measures in these cases much sooner than they otherwise could be done, thus preventing long periods of invalidism and extensive destruction of the joints.

Tuberculous abscesses and sinuses heal under the influence of streptomycin, provided the primary focus is dealt with surgically at the same time.

The influence of streptomycin on chronic lesions has not been determined. There is the possibility of making the organisms streptomycin-resistant, thus rendering the drug ineffective if it should be needed at some future time.

Smith regards the effect of streptomycin as short-lived. The drug enables the surgeon to operate on patients whom he otherwise would not be able to treat surgically. It affects the course of the disease during the brief period while it is given, so that surgical treatment has a better chance to succeed. One should still depend fundamentally on surgery and not on streptomycin.

Observations on patients treated at the Orthopedic and Traumatologic Clinic of the University of Rome showed that streptomycin and para-amino-salicylic acid are efficient not only in the treatment of tuberculous abscesses and fistulas but also in the therapy of the primary disease.

The administration of the drugs should be continued until definite improvement can be observed clinically and roentgenographically. The optimal effect of streptomycin is obtained in a medium with a pH of approximately 9. Lower levels inactivate streptomycin. Toxic manifestations such as fever, headache and nausea are usually caused by impurities in the product.

The tendency of caseous or granulomatous lesions to create a fibrous capsule may prevent the antibiotic from reaching the lesion In such instances the local application of the antibiotic is advisable

Para-amino salicylic acid may also be employed locally in the form of a 20 per cent solution, using from 5 to 10 cc for each instillation

Pietrogrande made determinations of concentration of streptomycin in the blood, urine and pus of patients with osteoarticular tuberculosis, treated with this drug

Biochemical studies revealed that under the influence of streptomycin the pH of the pus and the sodium chloride and calcium content of the blood rise while the protein content of the pus and the refractometric index of the pus and of articular exudates fall

Streptomycin exerts its optimal effect in an alkaline medium Caseous and granulomatous tuberculous lesions are relatively impermeable to streptomycin Hence the local application of streptomycin is preferable to other modes of administration

Bosworth finds that streptomycin has an action far beyond its inhibitory one on the organism Its most outstanding action is the dramatic change it causes in the physical condition of the patient It provides the surgeon clinical material which is operable It appreciably *decreases the spread* of the tubercle bacillus The ordinary wide spreading of the incisional areas which break down is infrequently seen when streptomycin is given in advance of surgery In "closed" cases the action of the drug is not so dramatic as in those with sinuses where it is truly a lifesaving drug

Streptomycin in Tuberculous Bone and Joint Lesions with Mixed Infection and Sinuses —Bosworth Pietra and Farrell report that healing of sinuses occurred in 79 of 95 patients after treatment with 0 5 to 2 Gm streptomycin daily for ninety to one hundred twenty days The 16 failures were due to sequestra, thick-walled abscesses uncollapsed bony pockets inadequate stabilizing surgery or insufficient dosage

Streptomycin makes surgery possible in some instances Frequently decompression and drainage are not satisfactory Surgical eradication of extremely thick-walled abscesses *especially about the spine*, is not always possible Excisional surgery of abscesses and granulation tissue at the time of arthrodesis of other joints is possible Sequestrectomy is essential when it can be accomplished Arthrodesis is essential if healing is to be secured One cannot rely on streptomycin alone

Headache vertigo nausea vomiting or allergic manifestations occurred occasionally necessitating diminution of dosage or a short interruption in some cases

Viable organisms may persist for some time and reactivation may occur much later Clinically, however, retardation of the progress of the unopened lesion and improvement of general health have been noted during the administration of streptomycin on about the same basis as in the patients with sinuses It is doubtful whether streptomycin alone can heal any bone or joint lesion permanently

Orell believes that the use of chemotherapeutic and antibiotic agents has opened up increased possibilities of treating bone and joint lesions by radical operation that the abscesses as a rule heal primarily after the

withdrawal of the content, and that improvement of the patient's general condition follows These facts render it highly probable that the period of treatment can be considerably shortened, especially if the risk of relapse can be eliminated by operation

Tuberculosis is a general disease which responds to chemotherapeutics and antibiotics So long as the lesions are accessible to streptomycin or any other drugs introduced into the blood stream, they will respond and heal When local lesions and large areas of necrotic tissue and purulent foci have developed, general treatment alone is not effective A local approach is then necessary The lesions must be evacuated radically by surgery with the application of streptomycin, as dry powder, to the operative wound

Mild forms of tuberculosis should thus clear up with internal local and general treatment using short courses of streptomycin with PAS as basic medication

Orell found the combination of chemotherapy, particularly the administration of streptomycin parenterally or as dry powder locally increases the possibilities of radical treatment About 250 patients have been operated on under a "streptomycin umbrella" and primary healing was obtained in all cases Sinus formation, prolonged suppuration and reappearance of the tuberculosis have not occurred, not even after operations performed during the early stages of the disease Radical surgery seems to be effective when streptomycin and penicillin, as dry powder, are applied locally to the wound

Paravertebral abscesses were opened by Hirsch and emptied in 14 cases, 9 lumbar and 5 thoracic Before the operation the patients were given ½ gm streptomycin twice daily and also 14 gr PAS and 500,000 units of penicillin for two or three days At operation ½ gm of streptomycin and 500 000 units of penicillin were placed locally in the abscess in powder form After the operation the patients were given streptomycin for fourteen days, PAS and penicillin were also employed during the same period Then the PAS treatment was continued for some months The results with respect to general condition and temperature were favorable, and the radiological changes shown by the former abscesses, disappeared in most cases

Brock reported excellent results in draining tuberculous sinuses by giving streptomycin intramuscularly every four hours over periods of from ninety to one hundred and fifty days It may be that certain of these sinuses would yield to treatment in shorter periods of time with less streptomycin, if the streptomycin were injected locally around the sinus tracts

Pasem Sodium (Sodium Para-Aminosalicylate) (PAS) —Pasem Sodium inhibits the growth of tubercle bacilli *in vitro* and *in vivo* It has no bacteriolytic properties Pasem Sodium can only retard the further spread of infection and check further damage by the bacterial invader It can not restore tissue which has been damaged by the tubercle bacillus but it can place the body in a more favorable condition to repair such damage Pasem Sodium should therefore be regarded as an adjunct to treatment, not as a replacement for surgery Its chief value lies in its use as a supplement of the streptomycins Pasem Sodium may be indicated alone in tuberculous infections in which the bacilli have become resistant to the streptomycins

Pasem Sodium alone may also be indicated in infections which are deeply entrenched, especially when surgery is anticipated. Streptomycin should be given at the time of spinal fusion. One gm of dihydrostreptomycin should be given twice a week with sodium para-aminosalicylic acid for four to six months or until the micro-organisms develop resistance.

Carr, Karlson and Bridge found that premedication with benemid influences the metabolism and excretion of PAS so as to increase the concentration of PAS in the serum. The *in vitro* tuberculostatic potency of the serum is directly proportional to the concentration of PAS. The *in vitro* tuberculostatic potency of the serum is the same per milligram of PAS in the serum, whether that concentration is obtained by giving PAS alone or with benemid.

Para-aminosalicylic acid is now accepted as a valuable drug in the antimicrobial therapy of tuberculosis. Serious toxic reactions are uncommon, but many patients are unable to take the recommended daily dose of 12 gm because of gastro-intestinal irritation.

Beyer and his associates reported that benemid inhibited the enzymatic combination of PAS with glycine to form para-aminosalicyluric acid. A single dose of PAS was increased twofold to fourfold by premedication with benemid. The effect produced by benemid continues for months. Long-term therapy is safe. Administration of benemid together with the usual dose of PAS would increase the concentration of PAS in the blood and presumably would increase the therapeutic effect. Of more clinical importance is the probability that a smaller daily dose of PAS combined with benemid would be as effective therapeutically as larger doses of PAS alone.

It has been stated that bacilli potentially resistant to either streptomycin or isoniazid are killed by subinhibitory concentrations of the two drugs acting simultaneously. Isoniazid is likely to prove more effective than PAS in the control of streptomycin resistant variants because of its capacity to kill intracellular tubercle bacilli. PAS is almost completely inactive against the intracellular organisms. Combined use of streptomycin and isoniazid results in an acceleration of the death rate of both intracellular and extracellular tubercle bacilli.

Marsilid in the Treatment of Vertebral Lesions.—Bosworth, Wright and Fielding find that improvement occurred as follows: First—the temperatures universally decreased. Second—the general feeling of well being returned, pain receded rapidly, appetite and nutritional status improved, and uninterrupted sleep became possible. Third—The sinus washings which were positive became negative after four weeks. Marsilid has no effect on organisms other than the tubercle bacillus.

Results in a group of patients treated by Selikoff and associates with combinations of streptomycin and the hydrazide derivatives give promise of enhanced superiority over each independently. They found that combinations of hydrazide and p-aminosalicylic acid are well tolerated.

The Use of Iproniazid in the Treatment of Vertebral Tuberculosis.—Bosworth and associates reported on the use of iproniazid on 66 patients with tuberculosis of bones and joints. Among these patients there were 98 tuberculous lesions; 45 of these healed, 37 improved and 16 are unimproved. Included are a few tuberculous lesions not involving the

osseous system, but exclusive of pulmonary tuberculosis (skin, peritoneum, meninges, *et cetera*) No adverse findings have resulted from prolonged medication when dosage has been held within proper limits They noted no cumulative effect Further work on circulating eosinophils is advisable

Ipromazid has a great effect in the control of bone and joint infection by the *Mycobacterium tuberculosis* Bosworth's group believe that ipromazid is the drug of choice in the treatment of tuberculous bone and joint lesions Patients under medication exhibit multiple evidences of toxicity All these are mild or reversible and appear unimportant, except possibly psychosis Ipromazid therapy must be combined with good medical care, dietary care, and surgery when indicated It may be that, by the use of this drug in children, a tuberculous weight-bearing joint may be spared arthrodesis

Evans, made the following points

1 Tuberculosis is a generalized systemic disease the care of which requires the teamwork of all concerned The surgeon is only an adjunct to that care and contributes within the limits of his knowledge and skill He is a member of a coordinated team

2 Tuberculosis is never healed except by total ablation It is only clinically arrested

3 The review by Ghormley, Bickel, and Evans has shown that twenty-eight to thirty months is the average minimum observation period required to declare a tuberculous bone lesion irreversible

The goal for treatment of bone tuberculosis must be the eradication of tuberculous foci This is possible to a greater extent and in more patients by the use of streptomycin and para-aminosalicylic acid in addition to surgery Ipromazid seems to penetrate synovial membranes very freely

A tuberculous abscess arising from a tuberculous costal cartilage was successfully treated by Koontz by aspiration of the contents of the abscess cavity and immediate injection of streptomycin into the cavity Surgical treatment is easier and safer when carried out in conjunction with streptomycin Sooner or later most osseous lesions have to be treated by surgical stabilization Streptomycin alone has not proved as effective as streptomycin combined with surgical measures McBurney found streptomycin to be a valuable adjunct in the treatment of complications or severe sepsis

Two hundred lesions under observation for three years seem to have been arrested by treatment with streptomycin Ghormley sums up the observations of several authorities on 750 cases Only proved cases should be accepted for study

At the suggestion of Dr Smith a study has been in progress at the New York Orthopaedic Hospital for over three years on the use of streptomycin as an adjunct in the surgical treatment of bone and joint tuberculosis This is under the supervision of Dr Horace Yu

The antibiotic has proved to be of great value in closing sinuses, and by controlling exudative and the more active lesions in assuring a favorable surgical outcome

Penicillin and dihydrostreptomycin are administered the day before operation and continued for five days postoperatively

Derov and Fisher recommend the following plan

1 Adequate open drainage

2. Removal of sequestra
3. Conversion of abscess to a freely draining sinus with gauze packing
4. Administration of streptomycin
5. Splinting of joints postoperatively
6. Encouragement of active motion in peripheral joints
7. Improvement in general nutrition and treatment of anemia
8. Dihydrostreptomycin in cases of toxic reaction to streptomycin

The Nicotinamides.—The discovery of the nicotinamides purports to be one of the great advances of modern times. These drugs are valuable as supplements to streptomycin. They show remarkable activity against the tubercle bacillus in the test tube, in the experimental animal, and in man.

In the experimentally infected animal they appear to have advantages over agents previously used. They are quantitatively more effective than streptomycin, p-aminosalicylic acid, niacinamide, or any of the thiosemicarbazones tested. They differ qualitatively from these agents in that they appear to be bactericidal rather than bacteriostatic. Following treatment of animals with any of these preparations, viable tubercle bacilli can be recovered on culture even in the absence of gross lesions. Following treatment with *isonicotinic acid hydrazide or its isopropyl derivative, no bacilli* can be found in the majority of animals. Moreover, pulmonary lesions do not appear within twenty-one days after cessation of therapy, as they do in animals treated with other tuberculostatic drugs.

Appreciable concentrations of drug are present in the spinal fluid within three hours after an oral dose of 2 to 3 mg. per kilogram in patients without meningitis. In patients with tuberculous meningitis, the concentrations in the spinal fluid are substantially higher than the concentrations necessary to inhibit M. tuberculosis *in vitro*.

No clinical evidence of bacterial resistance has been encountered.

At the London Convention in 1952 Bosworth reported on the use of the isonicotinic acid derivatives, rimiform and marsilid, in the treatment of bone tuberculosis. Some of his results were amazing. There is no doubt that these drugs are destined to be most useful adjuncts to present therapy.

An editorial in the Journal of The American Medical Association advises most emphatically that isoniazid be employed only in multiple combinations with streptomycin and p-aminosalicylic or other chemotherapeutic agents active against mycobacteria and not related by cross resistance.

Non-spinal Psoas Abscesses.—Baer, Bennett and Nichlas called attention to a group of cases of psoas abscesses which *originate from sources* other than spinal or pelvic bone disease. They found that lymphadenitis of the retroperitoneal nodes exists with either a tuberculous or a septic organism as the infective agent, and that the conditions must be clearly differentiated *from vertebral or hip joint disease*.

Surgical Approach.—An incision is made over the crest of the ilium, from the anterior superior spine backward a distance of eight cms. The incision is carried through the external and internal oblique muscles and transversalis fascia to the peritoneum, which is then stripped forward to expose the psoas muscle. Through this incision, examination can be made from as high as the kidney to as low as just beyond the linea terminalis. Treatment of the abscess will then follow accepted surgical principles.

Zadek reported 7 cases of acute psoas abscess of non-tuberculous origin none of which was the result of direct extension from a pelvic organ All of the patients were operated upon and every one recovered

In all of these patients, the pus was found within the psoas sheath in the substance of the muscle No evidence of necrotic lymph node tissue was observed It is conceivable that an accumulation of blood in the muscle could act as a culture medium for the development of the abscess

The psoas is large and of considerable substance It is the most important flexor of the hip and is used in standing walking, and sitting

Some Notes on Tuberculosis of the Vertebræ

Patients with tuberculosis are being concentrated in a few centers
Tuberculosis is a blood stream infection
The bone is primarily infected
The disk is affected secondarily and late

Pott s Paraplegia—Paralysis due to Vertebral Tuberculosis

Percival Pott presented, in 1779, his "Remarks on That Kind of Palsy of the Lower Limbs, Which is Frequently Found to Accompany a Curvature

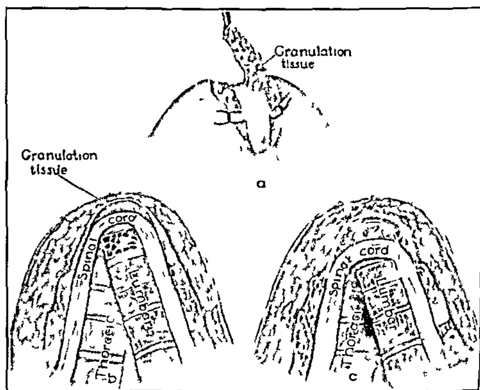


Fig 149—The condition present and the surgical procedure which was carried out to relieve the compression of the spinal cord (a) Removal of the extradural granulation tissue and ligation and division of nerve roots (b) Sagittal plane showing the marked kyphosis and angulation and compression of the spinal cord between the granulation tissue and the diseased bone (c) The spinal cord transplanted to a new position and thus relieved of pressure (Love and Erb courtesy of Arch Surg)

of the Spine and is Supposed to Be Caused By It Together With Its Method of Cure" (in Miscellanea Medica X, London, 1779)

Ridlon in 1916, called attention to the fact that Jean Pierre David had given a description of this condition a year before Potts did

This condition is of great interest in certain orthopedic centers and is practically unknown in others

There has been renewed interest in the subject due chiefly to the excellent contribution of Bosworth and his associates

Others who have made noteworthy contributions are Sorrel, Sorrel-Dejerine, Girdlestone, Seddon, Butler, Cleveland, Pietra and Rahilly, Love and Erb, Gareau and Brady, Kite, Calot, Calve and Capener

Paraplegia is due to pressure of the tuberculous exudate on the spinal cord and its peripheral nerves There may be thickening of the meninges caused by extension of the disease from the original bone focus It may be due to the presence of an abscess which breaks through into the spinal canal, to the development of granulations within the canal to edema or to sequestration of a portion of bone from the vertebral body or pedicle

Kite and others believe that the paralysis is not caused by stretching of the cord over a sharp angle of bone because many of the non-paralyzed patients show a greater kyphos than do those who were paralyzed Paralysis in the early cases is caused by pressure from the products of inflammation

The following descriptive terms are used

1 Paraplegia in extension
2 Paraplegia in flexion
3 Paraplegia with flaccidity
4 The syndrome in which neurological signs of paraplegia appear before there is roentgenographic evidence of tuberculosis of the vertebrae

Gareau and Brady emphasize the fact that Pott's paraplegia presents a problem involving grave risk to the patient and considerable labor on the part of medical and nursing personnel

The lesions of the spine are usually in the thoracic or thoracolumbar vertebrae

Bosworth Della Pietra and Rahilly made an intensive study at Sea View Hospital of 122 patients who had paraplegia due to tuberculosis of the spine During a fourteen-year period there were 510 patients admitted with tuberculosis of the spine The incidence of paraplegia was 24 per cent The average age was thirty years the oldest being sixty-nine years and the youngest two years Color and sex had no specific influence on the success of treatment

There were 10 paraplegics between the ages of two and five years There were 5 between the ages of five and ten years In 15 instances paraplegia occurred below the age of ten These children had the most favorable outcome There were 75 paraplegics among whom there was thought to be a possibility of salvage

Status of the Paralysis —99 of the 122 patients had complete motor and sensory paraplegia Twenty-three had paresis or partial paralysis Each of these had a sustained clonus and varying amounts of motor weakness and sensory loss Incipient paraplegia that is not permitted to go on to total loss of

function has a much better prognosis than where complete paraplegia exists Only 1 of 23 patients with paresis succumbed, while 68 of 99 patients with paraplegia died In order to prevent a paresis from developing into a full blown paraplegia one must make an early recognition and perform prompt surgery With such care the prognosis of permanent recovery is excellent With late diagnosis of extradural pressure and conservative treatment, the outlook is poor Early recognition demands the observation of clonus and reflex changes including the Babinski test The outstanding early objective sign is clonus

Diagnosis —Diagnosis rests upon the known fact of tuberculous involvement of the spine plus a sustained clonus Other findings of gradually increased pressure such as a Babinski, weakness and sensory change eventuating in complete paraplegia, may be present Since epidural tuberculous abscesses extend beyond recognizable limits, spinal puncture must be avoided Meningitis may result from dural puncture All of the 122 paraplegics were of the spastic type except for one

In the main, paraplegia is associated with thoracic spine disease In 115 patients the thoracic area was involved All had paraplegia In 6, the cervical region was invaded All of these had quadriplegia One instance involved the low lumbar region with a flaccid cauda equina type of paralysis

The treatment of paralysis due to tuberculosis of the spine consists of traction extension immobilization, aspiration and operation Sorrel and Sorrel-Dejerine advised extension and immobilization Calve recommended aspiration of the abscess by means of a special trocar which provides an outlet for the abscess located in front of and compressing the spinal cord A curved trocar is introduced into the anterior extradural space through the intervertebral space Pus appears in the instrument immediately after puncture This method of puncture, performed 66 times, never provoked any ill-effect Voltancoli advised drainage with a trocar introduced into the mediastinum when the abscess was located in the midthoracic area

Girdlestone expressed the belief that Pott's paraplegia in children can, as a rule, be avoided or quickly cured by conservative treatment, but that in adults operation is generally indicated He advocated early decompression in adults This may take the form of laminectomy, costotransversectomy or both but whatever the method of decompression, he considered stabilization by bone grafting of the diseased part of the spine an essential complement

Steindler finds that paraplegia yields to recumbency and extension in the vast majority of children In adults and those of more advanced age however, there are more and more failures following this treatment It is advisable to be conservative and patient in the management of compression paraplegia and to allow sufficient time for the effect of conservative treatment to become manifest It is equally necessary however, to recognize promptly many exceptions which will resist conservative treatment and will demand operative measures so that the operation may be performed before signs of sensory disturbance and flaccidity have appeared

The various operative procedures besides the Albee the Hibbs and their modifications, are laminectomy and the laminotomy of Fraser Costo-

transversectomy consists in the removal of the lateral ends of the transverse processes with their rib attachments

Girdlestone expressed the opinion that in adults early decompression is indicated to protect the spinal cord from prolonged pressure and the patient from the complications of paraplegia Grafting leads to complete local immobilization of the spine which protects the spinal column from further erosion and promotes healing of the lesion

Aspiration of a posterior mediastinal abscess associated with tuberculosis of the thoracic spine is a formidable procedure In patients who are developing or have developed paraplegia, however, and who show an abscess shadow in the thoracic region which is not too heavily calcified, Bosworth has had some success in aspirating the abscess washing it out with saline solution and producing an apparent decompression of the spinal lesion In cases where there is considerable doubt as to diagnosis between tuberculosis and malignancy aspiration of the posterior mediastinum is justified for diagnosis alone

Retroperitoneal biopsy of questionable lesions of the lumbar spine is occasionally justified to enable one to correctly differentiate between tuberculosis and neoplasm

Treatment —Treatment is divided into conservative and surgical

1 Conservative treatment includes rest on a hyperextension frame and extension

2 Laminectomy is justifiable only for relief of abscess and tension

3 Direct operation on the diseased area is the best

4 Direct fusion if no laminectomy has been performed

5 Circumduction fusion is advised if laminectomy has been previously performed

Streptomycin and the nicotinamides should be given before and after surgery Body weight should be maintained Blood transfusions are essential

Dott and Seddon find that an antero lateral decompression of the diseased area affords excellent visualization of the contents of the vertebral canal and the pathological changes therein It provides access to the anterior aspect of the theca The neurological recovery following this operation has been very satisfactory, and rapid The operation is virtually an extensive costo transversectomy

A successful surgical fusion of the spine and prolonged bed rest offer the best means of relieving the situation

Laminectomy seems futile to Garceau, because it fails to relieve the pressure on the ventral and lateral surfaces of the spinal cord which is usually exerted by the abscess It interferes with the surgical stabilization of the diseased spine which is so essential to the ultimate arrest of the process Most cord recovered cases will benefit and gain in security by bone grafting during an appropriate period

Garceau Cleveland Kite and Bosworth believe that early spine-fusion operation and rest will prevent paraplegia Eleven of Garceau's 32 patients had had spine-fusion operations before the onset of the paraplegia In only one of these patients was an unsound fusion found at the time of operation for the relief of the paraplegia Cleveland's experience is comparable to Garceau's

Bosworth and his associates believe that laminectomy has no place in the treatment. They advise decompression of an abscess but not of a vertebra.

Garceau's experience confirms the teachings of Hibbs and others, that early spine fusion is the best treatment for tuberculosis of the spine. Garceau reported 50 cases treated by fusion and compared these with 50 treated without fusion. Every patient who had had adequate fusion had a good result. Since early fusion is now being performed in tuberculous spines, paraplegia has become less frequent. Prevention of paraplegia by early spine fusion is the treatment of choice.

Bosworth is in full agreement with Garceau and Brady that paraplegic should not be allowed to remain paralyzed indefinitely. Drainage of a psoas, lumbar or mediastinal abscess by aspiration or incision should be performed to relieve spinal-cord pressure. By the use of streptomycin as an adjuvant a good many of these abscesses may be incised and drained, with immediate closure of the wound.

Anterior decompression in disease of the thoracic spine to relieve the pressure of an abscess and bone detritus, or both, should be preceded by spine fusion.

Bosworth and associates describe the treatment of paraplegia at Sea View Hospital. Their whole concept of treatment for paraplegia associated with tuberculosis of the spine has been based on the pathological findings. Paraplegia in the main develops from extradural pressure from abscess formation. Collapse and bony fragmentation pressure causes a minority of the cases. True transverse myelitis from pressure is unusual. Bosworth's associates believed that 80 per cent of the paraplegia associated with tuberculosis of the spine would recover with adequate surgical fusion and recession of abscess pressure.

A solid spinal fusion is essential to permanent recovery from paraplegia in tuberculous spinal disease. Some patients recover from paraplegia on enforced bed rest only to have recurrence of paraplegia on becoming ambulatory. Spinal fusion will provide relief.

There were 14 patients admitted to Sea View Hospital with laminectomy defects of from two to six segments. Of these all are dead except four who were treated by circumduction fusion. Three of these have been completed and the patients discharged with essentially normal activity. All are recovered as to paraplegia including recovery of control of bladder, bowel and lower extremities. One has had completion of circumduction fusion done and is ambulatory.

In following the records of laminectomy procedures, at other institutions from which these patients came it is noteworthy that a number of them improved considerably immediately postlaminectomy only to recur as to paraplegia within three months and eventually die.

Even in the cases saved by circumduction fusion tremendous surgical effort and hazard was necessary because of the laminectomy and the lack of posterior spinal elements for direct fusion fixation.

The concept of *circumduction fusion* was developed for inoperable cases due to posterior element tuberculous disease with mixed infection. It has

been used to bypass the defect area in these disastrous cases on whom laminectomy had been performed.

Since with adequate spinal fusion recovery from paraplegia remains permanent and with laminectomy fatalities are inevitable, there would seem to be no choice between the two procedures.



Fig. 160. Cross section specimen shows pressure by a sequestrum and growth of granulation tissue into the vertebral canal. (Garceau and Brady; courtesy of J. Bone and Joint Surg.)

Bed rest, high caloric high protein diet, streptomycin therapy and all other forms of supportive treatment were used on these patients as soon as available. No plaster jackets nor brace supports were used either for the spinal fusion procedures or the circumduction fusions. No retention of the patients on Bradford frames, Stryker frames or other supports was used. Firm mattress support was routine.

Deaths.—Sixty-nine of 122 patients with paraplegia died at Sea View: 56.5 per cent mortality. Forty-seven patients were estimated as hopelessly involved on reception at the hospital and all of these died without surgery. Of the 75 they attempted to save, 22 died: 29.3 per cent mortality.

The causes of death in the 22 patients they attempted to save were as follows: Six died of continued paraplegia associated with laminectomy

3 of them with massive decubiti and 3 with breakdown of the laminectomy incisional wounds Six patients died with meningitis Five died of advancing pulmonary disease Two succumbed with multiple osseous lesions and overwhelming tuberculous infection Two patients with posterior element tuberculosis died of postoperative infection One died with amyloidosis

Bosworth and his associates concluded that laminectomy has no place in the treatment of paraplegia associated with tuberculous disease of the spine Spinal fusion is essential In the neglected cases admitted to Sea View Hospital paraplegia was of serious import and such cases developed a mortality rate of 56 55 per cent Of 122 patients 53 survived No patient survived who did not have a solid spine fusion Of the survivors 62 26 per cent recovered completely, 24 52 per cent recovered to a considerable extent, and 13 22 per cent showed no improvement in their paraplegia Circumduction fusion and the advent of streptomycin have remarkably improved the outlook

Because of the marked angulation of the vertebral column found in the late stage, Love and Erb employed a procedure designed to free the cord of its compression and also to allow it to assume a more normal relationship which seemed to be preferable to a decompressive laminectomy Hyndman in 1947 described a technic for both anterior and lateral transplantations of the spinal cord in cases in which marked kyphosis or scoliosis existed It was his belief that in the majority of cases granulation tissue was the cause of the paralysis and that this procedure had no special application in the treatment of tuberculous kyphosis with signs referable to the cord He also called attention to the use of anterior transplantation of the spinal cord for acute injuries followed by rapidly developing paralysis

Love and Erb reported 5 cases of anterior transplantation of the spinal cord with the belief that this procedure has some value in the treatment of Pott's disease with associated paralysis

SYPHILIS OF THE VERTEBRÆ

Syphilis of the spine may be manifested by periostitis, arthritis osteitis or neuropathic arthropathy Periostitis may or may not be demonstrable in the roentgenogram Gumma may occur as in any other bone

The lesion produced by a gumma was differentiated from that produced by tuberculosis by Brailsford who stated that while the latter is generally associated with bone atrophy and little new bone production the gumma destroys the bone within its borders but gives rise to sclerosis and proliferation of the tissues surrounding it

The deformity of the vertebral body in syphilis is not characteristic but there is usually localized destruction from gumma or in the later stages, a marked increase in the calcium content of the body, variation in contour and extensive bony overgrowths at the vertebral margins

Syphilis may be manifested by a gumma which is painless unless the periosteum is involved by erosion of cartilage or by a diffuse, periosteal thickening under the anterior spinal ligaments

The complement-fixation tests are positive or modified by treatment. The therapeutic test with mercury, iodides, arsenic or bismuth is helpful in making the diagnosis. Charcot or neuropathic spine due to syphilis, is characterized by much destruction of bone, and collapse of the vertebra, but without clinical symptoms in proportion.

Cofield and Little stated that routine examination of the spine is secondary, and among cases of tertiary syphilis there is probably a high proportion of spondylitis of the arthralgic type.

The gummatous type of spondylitis is often difficult to differentiate from tuberculosis of the spine, the most notable contrasts being less pain on motion, less sensitiveness over the lesion, less muscle spasm, and improvement of the condition after antisyphilitic treatment.

Penicillin has revolutionized the treatment.

SYPHILITIC ARTHRITIS OF THE VERTEBRÆ

Syphilitic arthritis may manifest itself during the secondary or tertiary stages of the disease. In a neurological examination, a joint puncture with complement-fixation tests and cytological examination of the fluid, and Wassermann and Kahn tests on the blood should be done as a routine in every case of arthritis.

In tabes dorsalis, syringomyelia and other chronic diseases of the spinal cord, or of the peripheral nerves, joint changes occur which depend upon neurological lesions. The sudden onset, the marked enlargement of a single joint, and the absence of severe pain are characteristic. In addition to bizarre, monstrous hypertrophic lesions which predominate in the roentgenogram, there are excrescences on the bone and huge calcified masses in the extracapsular tissues, regressive, atrophic or absorptive changes and usually extreme disintegration of the joint in advanced stages. Early marginal fractures may occur. Kling found that a positive Wassermann reaction in the joint fluid, in combination with negative other findings, is the most important proof of the syphilitic nature of a joint affection.

OSTEOMYELITIS OF THE SPINE

Vertebral Osteomyelitis

Osteomyelitis of the spine is a serious disease. An early diagnosis is important because early operation is so effective and delay in treatment so serious. The condition is difficult to diagnose, it has a high mortality and is likely to have serious complications.

The first cases of osteomyelitis of the vertebræ were reported by Lannelongue in 1879. In 1895 and 1899 Hahn published his reports. In the records of 578 cases of osteomyelitis of all bones reviewed by Wilensky in a New York hospital, the spine was affected in 1.5 per cent.

Kulowski published a paper on pyogenic osteomyelitis* of the spine based on 102 cases, 60 of which were observed at the University Hospital, Iowa City, and 42 were investigated by questionnaire. This large series

* Osteomyelitis of the vertebræ is the same disease as osteomyelitis in other bones except for the anatomy involved, the structure of the bone, the shape of the bone, the circulation and the mechanics.

observed by Kulowski was partially accounted for by the rural environment from which most of these patients came, it being generally stated that pyogenic bone infection is more common in these districts. Almost 1 per cent of all cases hospitalized in these clinics are due to some form of pyogenic osteomyelitis.

The disease is common among adults although it predominates in the second and most active decade of life. Gamboa and Montaree reported the case of an infant aged forty days, with vertebral and costal osteomyelitis; in their opinion an umbilical infection was the portal of infection.

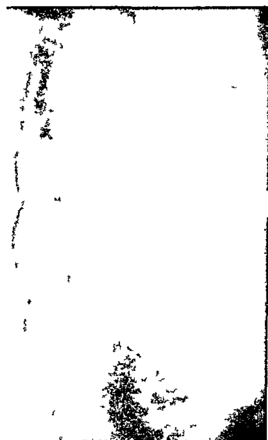


Fig. 104 — Infectious spondylitis following septic abortion. Note diminution of intervertebral space and irregularity of vertebral borders.

Any part of the vertebral system may be affected as Kulowski suggested but the disease attacks the bodies of the vertebræ sooner or later unless prompt and adequate treatment has been instituted. The thoracolumbar vertebræ are most frequently involved. In one case an infection of the leg followed the intrusion of a splinter; in another case a boil resulted in osteomyelitis of the tibia which metastasized into a vertebral body. One of my patients had had a recent septic abortion.

If the disease were kept in mind Kulowski believed its diagnosis could be made early but consideration of it he regarded as a primary factor in diagnosis. Clinically acute, subacute and chronic forms occur not contingent upon the extent of the lesion but upon the associated bacteremia

and other complications, particularly the rapidity with which suppuration and abscess ensues. The mortality is high. Kulowski urged that operative intervention was imperative as soon as the diagnosis could be made with reasonable certainty when suppuration is present or suspected in acute or chronic stages of the disease. Extent of the operation is necessarily limited by the operative risk and the important static function of the spine. "Secondary purulent infiltrations must continue to demand our primary consideration," continued Kulowski. "Adequate evacuation and continued drainage of such collections offer great difficulties." In general, they can best be overcome by observing Orr's principles. "It is an impressive lesson to observe at autopsy the presence of large pelvic and psoas abscesses after one had thought the local situation had been adequately taken care of. The primary spinal focus requires the first attention of the surgeon, and any pelvic purulent collection or infiltration should be attacked from every surface possible, to bring about its successful evacuation and continuous drainage. The lumbosacral lesions are particularly difficult to evaluate, clinically, especially after one or more of the sacro-iliac joints have become involved by extension."

No other area of the body reveals so clearly as does the spine that in the acute stage of pyogenic osteomyelitis one is dealing primarily with a septicemia. Until suppuration has occurred, the local skeletal manifestations are of secondary import. Patients who die during the early acute stages do so because of the intense general sepsis.

In treating these lesions, the rule of adequate drainage and rest should be followed as soon as the diagnosis is made and until further knowledge of the relation between the portal of entry of the infection, the septicemia, and the local condition contraindicates the advisability of such measures.

Pathological Changes.—Osteomyelitis of the vertebral bodies may develop as an epiphyseal separation, a rarefying osteitis, or as a subperiosteal or destructive ulcerative lesion. Usually a single vertebra is involved; occasionally the disease extends to two, three or more. It may be of a diffuse type in which the whole posterior arch is involved, including the spinous and transverse processes. Donati found that the spinous processes are affected most frequently, the pedicles next and the transverse processes less frequently.

Lazarus stated that whether the lesion be a carbuncle, a furuncle or an infection of the tonsil, the cause of spread from the focus to the point of the metastatic lesion is an infected thrombus, situated at or in the immediate neighborhood of the original lesion and communicating at some point with the general circulation.

The pathogenesis of acute osteomyelitis of a vertebra is that of a metastatic complication in the course of a general bacteremia starting from a primary focus of infection existing elsewhere in the body.

The pyogenic type is usually caused by Staphylococcus aureus. Steindler reported 12 cases. Acute pyogenic osteomyelitis of the spine is most common during the growing age, from twelve to fifteen years, during which the secondary centers of ossification of the spine make their appearance. Steindler was able to demonstrate a primary infectious focus in several of his cases.

History—Symptoms.—The onset is usually acute with localized pain and tenderness, fever, rigidity of the spine and other constitutional manifestations. A history of a primary infection is usually obtained. The pain referred generally to the back at first, becomes localized later. A history of injury is unusual, but the presence of skin lesions, such as boils or insect bites, or septic fingers or of a sore throat, is frequently noted. Occasionally there is a history of a chronic staphylococcal septicemia.

Fever may be very high.

Physical Findings.—The chief physical finding is rigidity of the area involved, owing to limitation of movement of the intervertebral joints and irritation of the spinal ligaments.

The clinical picture of the fulminating type of vertebral osteomyelitis is that of a profound infection ushered in with chills and high temperature. Pain is the earliest symptom. It may be general or localized, and is aggravated by *movement of the spine. Percussion over the affected bone* elicits marked tenderness. When the suppurative process has broken through the periosteum, an abscess forms.

Suppuration is a frequent, but not an invariable complication. The symptoms, which are usually those of the abscess rather than of the bone lesion, *will depend on the size and location of the former.*

There are three principal sites of abscess formation in disease of the vertebral bodies: (1) anterior, in which the abscess forms under the periosteum and enters the mediastinum or the retroperitoneal cavity, according to the location of the primary focus, (2) posterior, in which it progresses toward the dura, causing pachymeningitis and medullary compression, (3) lateral, in which it extends between the vertebral bodies and transverse processes. In the lumbar and low thoracic regions, the abscess may invade the psoas muscle sheath causing psoas contracture.

Roentgen-ray Findings.—Roentgenograms may not reveal any pathological changes for several days or weeks. The loss of the intervertebral disk space may precede the visualization of the destruction of surrounding bone.

According to Smith, a slight haziness and indistinctness of the bone structure may occur fairly early (especially in thoracic lesions). A fusiform paravertebral abscess shadow, resembling that found in tuberculosis, may be seen in the roentgenogram. Somewhat later, productive bone changes are seen about the periphery of the vertebral bodies and across the margins of the intervertebral spaces. There is a strong tendency to bony fusion of the bodies. The important roentgen observations in Smith's cases were: (1) thin intervertebral disk, (2) partial destruction of vertebral bodies with bony ankylosis, (3) partial destruction of bodies with probable ankylosis, and (4) destructive lesions of the posterior arches.

Laboratory Findings.—Leucocytosis is usually a predominant finding. The sedimentation rate is very high.

Diagnosis.—The sudden onset of symptoms of an acute infection accompanied by severe back pain should suggest the possibility of vertebral osteomyelitis. Roentgen ray examination is of little assistance during the early stages. During the period of observation one should be on the lookout for a localized paravertebral abscess. The most important diagnostic signs are

severe localized pain with rigidity of the spine. There may be circumscribed edema, localized acute tenderness, and radiculitis. Repeated confirmatory roentgenograms of the lumbar region showing obliteration of the psoas muscle shadow are valuable diagnostic aids. Complications may be very serious. They are systemic and metastatic. The lesions have a strong tendency to cause spontaneous bony fusion of the vertebral bodies.

Differential Diagnosis.—In the acute form, the early signs of purulent osteomyelitis of the vertebral bodies are not characteristic, hence errors in diagnosis are frequent. The symptoms may suggest rheumatic fever, acute arthritis, meningitis, typhoid fever, peritonitis, appendicitis, pleurisy or pneumonia. The diagnosis rests primarily on the local signs, that is, pressure pain, referred pain, induration, swelling and fluctuation. The most important symptom is pressure pain at the site of the disease and in the surrounding area. It usually appears early.

When situated in the lower thoracic or lumbar portion of the spine, the syndrome may simulate closely diseases of the kidney or perirenal tissues. Likewise the possibility of osteomyelitis should be borne in mind when perinephric abscess is suspected. Osteomyelitis of the vertebral bodies occurs frequently in a mild form which may easily be mistaken for tuberculosis.

Prognosis.—Acute vertebral osteomyelitis may be rapidly fatal due to the primary infection or to the complications. In the most severe and frequently fatal type of all, in which there are symptoms of a lesion of the spinal cord, the infection of the bone may be overlooked completely until the true nature of the disease has been revealed at postmortem examination. The degree of residual deformity in those who survive will depend on the amount of bone destruction.

Non-operative Treatment.—Conservative treatment is advised but meticulous watchful expectancy is imperative. Non-operative treatment of osteomyelitis includes use of staphylococcus antitoxin, sulfathiazole, bacteriophage and repeated blood transfusions. Toxoid is recommended by some authorities. The drug should be of value in disease of the vertebrae.

The advent of the antibiotics has modified the treatment and prognosis completely. Penicillin, Aureomycin and Erythrocin are the most effective. They should be given immediately and continued until sensitivity tests indicate the best drug.

A method of treating chronic osteomyelitis combining the use of aureomycin with surgical, chemical and enzymatic debridement has been described by Miller and Long. After the wound is exteriorized as much as possible, further debridement is achieved by use of Varidase Streptokinase-Streptodornase dissolved in 1:1000 aqueous Zephiran chloride solution containing aureomycin.

Operative Treatment.—In osteomyelitis of the spine every effort must be bent toward early recognition and early drainage. Operations on the vertebral bodies themselves are indicated when the condition is acute, when rapid and adequate drainage of a focus is imperative. In the lumbar region an incision along the external border of the sacrospinalis muscle is recommended with approach to the vertebral bodies from the lateral aspect.

In the thoracic region the approach to the vertebral body necessitates costotransversectomy This means removal of the transverse process with the adjacent portions of the head and neck of the rib For a cervical vertebral abscess the best incision is along the posterior border of the sternocleidomastoid muscle following the course of the scalene muscles to the anterior and lateral portions of the vertebral bodies

For the acute form, involving the vertebral bodies of the thoracic spine drainage of the bodies is best accomplished through costotransversectomy For the forms involving the arches and pedicles, the problems of recognition and of surgical intervention are much easier

Para- and prevertebral, retromediastinal and retroperitoneal abscesses require radical and speedy evacuation

Lazarus advised incision and gentle curettement of the diseased vertebra The treatment best suited to the type of disease most frequently encountered in which the bacteremia if present at all is of moderate virulence—consists of the release of pus and the removal of sufficient necrotic bone to control the infection without impairing the function of the spinal column

The second feature in the treatment is proper incision and drainage wherever and whenever possible, of residual abscesses which are complications of the osteomyelitis

Technic of Drainage of Abscesses —Retropharyngeal abscesses should be opened through the posterior pharyngeal wall only in cases of emergency otherwise it is better to drain through the lateral triangle of the neck Prevertebral and mediastinal abscesses can be reached by resection of the costotransverse articulation A psoas abscess is best approached through an anterior incision like that used for ligation of the common iliac artery In the drainage of a presacral abscess one may use the technic of Picque consisting of total or partial resection of the sacrum Drainage of an interspinal abscess necessitates a laminectomy whenever the disease is located in the neural arches

BRUCELLOSIS OF THE VERTEBRÆ—BRUCELLOSIS SPONDYLITIS (UNDULANT FEVER)

Undulant fever is an uncommon disease of the spine The cause is an organism called brucella melitensis which commonly affects cattle and swine

The organism is transmitted to human beings chiefly by the ingestion of infected milk or cream or other dairy products by contact with infected cattle sheep, goats horses hogs by contact with freshly killed meat of infected animals or with live cultures during scientific work

In 1938 Gould and Huddleson estimated that about 10 per cent of the population of the United States had become infected and were ill with brucellosis at any given time Evidence has accumulated that chronic brucellosis is even more common as well as more baffling in regard to diagnosis Harris who has incorporated his researches in a recent book on the subject believes that brucellosis is an important world wide public health problem The disease is most prevalent among human beings in

areas in which the infection of cattle hogs and goats commonly occurs i e in local, raw milk-consuming populations

The lesions are all rather late sequela of the infection occurring eight to twelve weeks after the acute onset, and have a definite tendency to self-limitation Suppurations on the whole are rare but there is a strong reaction in the periosteum similar to that of osteomyelitis

Involvements of bone occurring in osteomyelitis may include the skull ribs humerus metacarpals and femurs supported by roentgen ray evidence and cultural findings Smith and Labson found that bone is destroyed from the marrow outward

By far the most frequent complication is osteomyelitis of the vertebra, which, in the overwhelming majority of cases involves the lumbar part of the spine Up to 1939 57 cases were reported in the literature Bishop reported the fifty-seventh case of spondylitis complicating undulant fever Brucella suis was isolated from the blood stream soon after the development of the local lesion which occurred over a year after the initial infection The lesion in the lumbar region was treated by surgical fusion and the cervical lesions by support There was improvement after seven months

Kulowski pointed out that while the osseous system is usually attacked late in the course of brucellosis, it may be involved at the onset of the disease Often there is nothing to distinguish it from ordinary pyogenic osteomyelitis except the tendency to loculation and cortical reaction with absence of periosteal reaction There may be abscesses of the vertebra and the intervertebral disks

The clinical appearance is the result of the hematogenous localization of bacteria, ordinarily in the osseous marrow but exceptionally in the disk in young persons The roentgenogram demonstrates a spreading infiltrative process, in which there is a reactive proliferative phenomenon, characterized by endosteal and periosteal reaction The result is sclerosis of the body with hypertrophic spur formation There is little tendency to invasion of the paravertebral tissues

This spondylitic complication originates usually during the convalescent stage of undulant fever but may make its appearance at any time It is accompanied by a febrile reaction and is characterized by acuteness of symptoms and a benign clinical course

A case of proved Malta fever infection which ran a typical chronic course and was complicated during the disseminative stage by a low grade myositis selective in its distribution and ameliorated by the administration of brucellin and pyrotherapy was described by O Donoghue and Scott These authors believe that the association between the proved systemic infection and the muscle atrophies in their case justifies the conclusion that selective degenerative myositis may be another of the many complications arising from Malta fever in human beings

Symptoms —Other characteristic features of vertebral involvement in brucellosis are narrowing of the disk and reactive bone production, rarity of abscess formation benign course, tendency to self-limitation and response to conservative treatment Simpson described the symptoms of acute brucellosis as fatigue weakness loss of appetite, constipation, headache,

backache, cough, arthralgia, muscular pains, restlessness insomnia and signs of encephalitis, myelitis or meningitis, and sometimes in severe instances, vegetative endocarditis

The only procedure by which the diagnosis of brucellosis may be established is the cultivation and identification of the brucella organism Agglutination and cutaneous tests are of value in the diagnosis of acute brucellosis but they are inadequate for the diagnosis of the chronic form

Diagnosis —During an epidemic of melitensis brucellosis Huddleston had an opportunity to make a comparative study of four diagnostic tests These were blood cultures, skin tests, the agglutination and the phagocytosis tests On the basis of results of each of the laboratory tests too much reliance should not be placed on any one test to confirm the early diagnosis of clinical brucellosis Results of all the available tests must be carefully analyzed before a positive diagnosis is arrived at

Phalen, Prickman and Krusen based their diagnosis chiefly on the presence or history of remittent fever, the local signs and symptoms of spondylitis, a high sedimentation rate and the presence of a high titer of specific agglutinins for brucella organisms in the patients' blood

Brucellosis occurs primarily in rural areas Those who become infected have had direct contact with domestic animals In addition there are those who become infected by ingesting unpasteurized milk or milk products made from unpasteurized milk The majority of Spink's cases occurred in males between the ages of twenty and forty years

Differential Diagnosis —Undulant fever syphilis and osteo-arthritis produce roentgenological changes similar to those of vertebral tuberculosis

No specific characteristic pathological change has been described in the arthritic manifestations of brucella infection The changes noted resemble those found in hypertrophic as well as atrophic arthritis Suppurative arthritis has also been attributed to brucella infection as has hydrarthrosis

Myositis is a common accompaniment of acute or chronic brucellosis manifested either as a purely subjective symptom or occasionally as an objective finding Pain and soreness may affect the quadriceps group alone or may be accompanied by rigidity and swelling of other muscle groups for instance the pectorals One or both of the lumbar groups may be involved indistinguishably from common lumbago

Kulowski described 2 cases of osteomyelitis 2 of spondylitis and 1 case of arthritis due to brucella abortus infection The 2 cases of spondylitis involved the lumbar spine There were destructive changes in the inter-articular facets of the lower vertebra and radiographic evidence of a psoas abscess which yielded at operation brucella abortus

Hardy described the lesion as an eroding suppurating arthritis when occurring in the spine

Degenerative changes in bone are occasionally seen in brucellosis infection Repair evidently goes on steadily along with the destructive process

Treatment and Control —Incidence of the disease in man could be reduced if the owners of livestock used more caution in handling infected animals, their excreta and secretions and by proper pasteurization of all milk from infected animals used for human consumption

One of the most important things to bear in mind so far as the patient is concerned is to reassure him that brucellosis is a self-limiting disease,

that no matter what is done the majority of patients recover There is no question that aureomycin and terramycin are effective in the treatment

Treatment of Brucellosis with Aureomycin or Terramycin Combined with Dihydrostreptomycin —Two combinations of antibiotics have been used in treating culturally proved brucellosis

1 The simultaneous administration of aureomycin and dihydrostreptomycin

2 The simultaneous use of terramycin and dihydrostreptomycin

Herrell and Barber consider both combinations equally effective The recovery rate with either method has been 95 per cent The combined use of terramycin or aureomycin and dihydrostreptomycin is superior to any other currently available therapy Furthermore the undesirable toxic reactions sometimes experienced with other methods have not occurred

The plan of treatment consists of the daily administration of 3 gm of either aureomycin hydrochloride or terramycin hydrochloride by the oral route During the same period the patient receives 1 gm of dihydrostreptomycin sulfate by the intramuscular route

Patients who are acutely or seriously ill should be hospitalized for treatment However the method can be used satisfactorily for ambulatory patients The patient simply takes terramycin hydrochloride or aureomycin hydrochloride orally and reports to the office or dispensary morning and evening for the intramuscular injection of dihydrostreptomycin sulfate

In the presence of localizing forms of the disease the plan just presented is modified as follows The same dose of terramycin or aureomycin is administered orally for three to four weeks (usually 28 days) The daily dose of dihydrostreptomycin is reduced to 1 gm per day and is given by the intramuscular route in the amount of 0 5 gm each morning and evening

Benassi reported 28 cases of spondylitis and three instances of sacroiliitis due to undulant fever in all of which the abnormalities were observed roentgenographically In the acute form the roentgenologic findings may be negative When the course is prolonged the lowering of the intervertebral space followed by softening and necrosis of the adjacent body surfaces becomes manifest Notchlike erosions of the vertebral edges may be observed In rare cases extensive destruction with flattening is seen Osteosclerotic and osteophytic reactions are early and rapid, they are followed by a late phase of formation of ankylosing bridges between the vertebral bodies After recovery changes of an osteoarthritic type may be observed Roentgenologic study can aid in the differential diagnosis from Pott s disease and can indicate whether the disease is in the invasive phase or in the stages of repair and reaction Roentgenotherapy and short wave diathermy are effective

RARE INFECTIONS OF THE VERTEBRÆ

Typhoid Spine —Typhoid spine is a toxic condition which is a sequel to or a complication of typhoid fever There may be *periostitis osteitis* or a subperiosteal abscess There is usually roentgenological evidence of bony condensation and ankylosis of the involved vertebræ within three or four months "Typhoid-inoculation spine" may follow repeated protective

injections The chief symptoms are pain, weakness, stiffness, disability and muscle spasm The pain may be local or referred In some cases one finds ossification of the ligaments and intervertebral disks but no spur formation Sciatic radiation often accompanies a lesion of the lower lumbar vertebræ

In most recorded cases the disease occurred between the ages of twenty and thirty-five years In the majority of cases, the lumbar vertebræ are affected by diffuse periarthritis and perispondylitis involving the ligaments between the bodies of the vertebræ, resembling osteoarthritis

Pneumococcus Spine —The pneumococcus may produce a toxic osteitis periostitis or embolic osteomyelitis Chandler reported 2 cases of pneumococcic infection of the sacro-iliac joint complicating pregnancy Treatment was radical resection of the ilium

Meningococcus Spine —Billington, in 1924, published a paper on spondylitis complicating cerebrospinal meningitis He reported a group of 12 cases of lesions of this kind most of them in the lower lumbar region—in other words, in the region of spinal punctures Most of the patients were ex-soldiers Each had had an acute painful condition in the back starting during the acute or convalescent stage of their meningitis If the lumbar puncture needle is pushed too far forward striking the anterior wall of the canal it hits the disk or the margin of the body of the vertebra Passage through an infected region provides a fruitful means of inoculating that disk Granting the possibility of needle punctures as a causative factor particular care should be taken to avoid pushing the needle point far enough to strike the anterior wall of the canal, or otherwise traumatizing any part of the spinal column

The roentgen-ray findings in these cases were similar to those seen in some of Ghormley s cases and represent the results of acute infection of the intervertebral disks probably meningococcic

In 19 cases there was definite clinical evidence of spondylitis In 14 of these there was positive roentgen evidence In 12 of the 14 there were hypertrophic pathological changes only in the lower lumbar region (3d to 5th vertebræ) and in 8 of the 12 there was partial or complete destruction of a disk in the same region These facts together with the histories especially when the age of the patient, the time and nature of the onset and the course of a subacute infection of the spine are considered, form a fairly definite picture differing from that of other types of infectious spondylitis and pointing to the meningococcus as the causative organism

The spinal puncture needle may easily afford a direct means of inoculating the lower lumbar vertebræ and disks with the meningococcus and in view of the location of the disorder it appears probable that it is an important etiological factor The pathological changes in other regions present in 2 cases may have represented such metastatic infections as may occur with the involvement of joints of the extremities though apparently less often

Treatment of the spine lesion should be early prolonged immobilization Billington performed operations on two of them from three to four years after the onset with complete relief of their back symptoms

VERTEBRAL ACTINOMYCOSIS

Human actinomycosis, caused by a ray fungus, is often overlooked or incorrectly diagnosed as tuberculosis According to Parker, actinomycosis of the spine is an extremely malignant condition Simpson and McIntosh described 4 cases of actinomycosis of the vertebra Each case came to necropsy with a clinical diagnosis of tuberculosis of the spine In 2 of the cases the primary infection was in the lungs in the other 2 it was in the appendiceal region Spread of the actinomycotic process to the vertebræ was due to direct extension by means of dissecting sinus tracts and abscesses

From the answers to 26 questionnaires Mattson reported histories of animal to-man infection 15 patients or 57 per cent of those answering had treated cattle for lumpy jaw prior to onset of their infection while 2 had treated horses for suppurating wounds about the head and neck 11 patients who had no such history of exposure admitted a fondness for chewing grass and straw and habitually picking their teeth with the latter Every patient also had a history of dental caries and pyorrhea

Two conditions are necessary for infection to occur (1) an abrasion of the tissues (2) direct contact of some sort between the fungus and this abrasion

Pathological Changes — The *characteristic lesion is cortical erosion of* the vertebræ with an abscess while tuberculosis causes progressive destruction of the bodies with collapse producing angular deformity The pathognomonic 'ray fungi' should be looked for by the surgeon who first drains an actinomycotic abscess Subsequent secondary pyogenic infection renders the search more difficult Curettements of the wall of a sinus tract with histopathological examinations of the fragments will often establish the diagnosis after frequent examinations of the pus for actinomycetes have proved fruitless The finding of lipoid cells in the granulation tissue *lends support to the probability that the disease is actinomycosis*

Symptoms — The symptoms are backache tenderness and limitation of movement

Every inflammatory swelling of chronic or subacute nature with persistent and recurring sinus formation should be carefully investigated for this disease A negative smear on first examination does not rule out infection as the fungus is often difficult to find in the presence of mixed infection

Diagnosis —The diagnosis of actinomycosis of the spine depends on the demonstration of the typical fungus in the material which is discharged from the sinuses The disease should always be kept in mind in every case of atypical pulmonary tuberculosis and should be looked for in cases of chronic purulent bronchitis or bronchiectasis

Many other causes of psoas abscesses should be considered before a diagnosis of tuberculosis *is made* The development of multiple sinus tracts with brawny induration of the surrounding tissues and the persistent absence of tubercle bacilli should direct one s thoughts to a consideration of actinomycosis

injections The chief symptoms are pain, weakness, stiffness, disability and muscle spasm The pain may be local or referred In some cases one finds ossification of the ligaments and intervertebral disks but no spur formation Sciatic radiation often accompanies a lesion of the lower lumbar vertebræ

In most recorded cases the disease occurred between the ages of twenty and thirty-five years In the majority of cases, the lumbar vertebræ are affected by diffuse periarthritis and perispondylitis involving the ligaments between the bodies of the vertebræ, resembling osteoarthritis

Pneumococcus Spine —The pneumococcus may produce a toxic osteitis periostitis or embolic osteomyelitis Chandler reported 2 cases of pneumococcic infection of the sacro iliac joint complicating pregnancy Treatment was radical resection of the ilium

Meningococcus Spine —Billington, in 1924 published a paper on spondylitis complicating cerebrospinal meningitis He reported a group of 12 cases of lesions of this kind, most of them in the lower lumbar region—in other words in the region of spinal punctures Most of the patients were ex soldiers Each had had an acute painful condition in the back starting during the acute or convalescent stage of their meningitis If the lumbar puncture needle is pushed too far forward striking the anterior wall of the canal it hits the disk or the margin of the body of the vertebra Passage through an infected region provides a fruitful means of inoculating that disk Granting the possibility of needle punctures as a causative factor particular care should be taken to avoid pushing the needle point far enough to strike the anterior wall of the canal, or otherwise traumatizing any part of the spinal column

The roentgen-ray findings in these cases were similar to those seen in some of Ghormley s cases and represent the results of acute infection of the intervertebral disks probably meningococcic

In 19 cases there was definite clinical evidence of spondylitis In 14 of these there was positive roentgen evidence In 12 of the 14 there were hypertrophic pathological changes only in the lower lumbar region (3d to 5th vertebræ) and in 8 of the 12 there was partial or complete destruction of a disk in the same region These facts, together with the histories, especially when the age of the patient the time and nature of the onset and the course of a subacute infection of the spine are considered form a fairly definite picture differing from that of other types of infectious spondylitis and pointing to the meningococcus as the causative organism

The spinal puncture needle may easily afford a direct means of inoculating the lower lumbar vertebræ and disks with the meningococcus and in view of the location of the disorder it appears probable that it is an important etiological factor The pathological changes in other regions present in 2 cases may have represented such metastatic infections as may occur with the involvement of joints of the extremities though apparently less often

Treatment of the spine lesion should be early prolonged immobilization Billington performed operations on two of them from three to four years after the onset with complete relief of their back symptoms

The essential treatment is the administration of one of the antibiotics (preferably penicillin) and the sulphonamides. In most cases the organism is sensitive to penicillin and this drug will usually cure the patient if given in large enough doses for a sufficient time—1 million units a day continued for at least several weeks, usually several months, and in some cases for a year or two (with a few intermissions). If the organism is not sensitive to penicillin one may use streptomycin, chloromycetin or aureomycin.

There is remarkable response to treatment with penicillin.

OIDIOMYCOSIS

Oidiomycosis or coccidioidal granuloma is rare. It is due to the coccidioides immitis. It is sometimes called "California disease." Because it is never primary in the spine another focus should be sought. The diagnosis should be suspected when spinal symptoms appear in a person who is known to have had coccidioidal granuloma, either in the lungs or in the long bones.

Copper salts and thymol have been recommended in the treatment.

I have not seen any reports on treatment by antibiotics.

VERTEBRAL BLASTOMYCOSIS

Blastomycosis of the spine caused by blastomycetes is an extremely serious but rare condition. The favorite location according to Parker is the body of the vertebra, from which it extends into the pedicles, laminae, transverse and spinous processes and on to the ribs. The primary roentgen finding is localized necrosis that causes a lesion in which centers of completely dissolved bone lie immediately adjacent to intact spongy bone. The osteoporosis and decalcification are patchy. The treatment is unsatisfactory. Antibiotics should be tried individually or in combinations.

SPINAL DEFORMITY FOLLOWING TETANUS

Spinal Tetanus.—The first case of spinal deformity following tetanus was reported in 1907 by Lehndorff. Since Ehrlicher reviewed 10 cases and added 2 of his own in 1921 the number reported in the literature has steadily increased.

About 100 cases of vertebral lesions from tetanus have been reported in the course of forty years. Contanzo observed 12 and described 2 of them.

The upper thoracic vertebrae are most often involved with the fifth predominating. The lumbar vertebrae have been involved only three times. The cervical vertebrae are never involved. Males were more often the victims than females and four-fifths of the cases occurred between birth and the age of fifteen.

The roentgen aspects of the lesion show a progression from the slightest to the severest alterations. In one case there was a compression fracture of the second and third lumbar vertebrae. Barnett showed me an *x* ray of a child whose thoracic vertebrae were compressed 50%.

Tolserol, intravenously, should be tried.

Actinomycosis seldom involves the vertebral column Only four out of 670 patients with *actinomycosis reviewed by Sanford and Voelker (1925)* had rib or vertebral involvement In the past, the diagnosis has been difficult and the condition has often been mistaken for Pott's disease Among the reports of 60 cases of mycosis of the vertebral column Meyer and Gall (1935) found only 9 diagnosed correctly before death The mortality rate was at least 90 per cent

Cope enumerates the conditions for which actinomycosis of the vertebrae has been mistaken as tabes dorsalis, bilateral pulmonary tuberculosis tuberculous caries of the spine tuberculous glands in the mediastinum and carcinoma of the lung It must also be distinguished from septic osteomyelitis of the spine and from chronic lesions such as osteitis deformans From the orthopedic point of view spinal actinomycosis must be considered when diagnosing any subacute or chronic spinal condition Actinomycosis can generally be distinguished from tuberculosis of the spine by these facts the intervertebral disks are usually spared transverse processes and heads of the neighboring ribs are often attacked collapse of a vertebral body and kyphosis are uncommon, sclerosis is generally mingled with rarefaction and a radiograph may reveal the lattice pattern In both actinomycosis and tuberculosis abscess travels outward from the vertebra and follows definite routes along the psoas or backwards along the ribs the actinomycotic abscess which travels from the adjacent tissues to attack the vertebral column has no definite pointing place though it usually comes to the surface posteriorly

Septic osteomyelitis of the spine has a more acute onset and may give rise to the formation of sequestra—an occurrence almost unknown in spinal actinomycosis Rarefaction of the bodies is also seen in osteitis deformans and in fibrocystic disease but there are no general manifestations of chronic inflammation Secondary growths in the vertebrae usually cause much greater pain, especially on movement paraplegia is more common and the general symptoms of suppuration are absent Until ten years ago the outlook for actinomycosis of the spine was almost hopeless

Treatment —The treatment is radical surgical excision of all involved tissue Brickner injected methylene blue into the sinuses and performed radical excision Bevan recommended potassium iodide therapy Early treatment of superficial lesions is highly successful Hall reported a cure *in a case of actinomycosis following the use of sulfanilamide*

Five patients with actinomycotic infection were treated by Myers with thymol locally and systemically each one recovering The thymol is applied locally whenever possible in olive oil solution from 10 to 20 per cent in strength Systemic therapy with thymol is advisable in attacking the infection and preventing its spread to other parts of the body The drug may be given in crystal form in capsules, one dose a day in order to obtain a peak load in the circulation It should be given on an empty stomach to avoid retention and irritation of the stomach and to speed absorption and obtain as high a concentration in the circulation as possible Sinus tracts may require surgical repair following the destruction of the actinomycotic infection

Chapter 26

ARTHRITIS OF THE SPINE—GOUT—FIBROSITIS

ARTHRITIS of the vertebra differs from the same disease in other joints because of the anatomy and mechanics of the spine and especially because of the proximity to the spinal cord and spinal nerves.

Vertebral arthritis has certain characteristics which differentiate it from general arthritis, especially in the fact that *it so commonly remains localized in the spine.*

Arthritis of the vertebral joints is manifested by stiffness, pain, sensitiveness, and deformity. It produces atrophic and hypertrophic changes. The intervertebral joints are key points in the arthritis problem.

Classification of Arthritis.—The American Committee for the Study and Control of Rheumatism advises the classification of atrophic and hypertrophic arthritis. Nichols and Richardson used the terms proliferative or ankylosing (atrophic) and degenerative or non-ankylosing (hypertrophic). *The term rheumatoid arthritis is synonymous with atrophic and infectious.* The term degenerative joint disease is replacing the word osteoarthritis.

Historical Remarks.—Osteoarthritis of the spine was present in prehistoric specimens of man as revealed by the skeleton of Pithecanthropus erectus exhumed in Java and estimated to be 500 000 years old. It was also found in the Neanderthal man who dates back 25 000 years. The oldest Egyptian remains reveal the frequency of osteoarthritis of the spine. The skeletons in pre-Columbian mounds indicate that osteoarthritis of the spine was prevalent in the American Indians and their ancestors. I have in file the roentgenogram of a mummy that shows extensive hypertrophic or degenerative changes in the vertebræ. It has been estimated that there are 7 million arthritics in the United States.

Recent Advances.—The most important advances in the subject of arthritis during the past two decades have been:

1. The classification into
   a. rheumatoid } types
   b. degenerative }
2. The transfer of the etiology of "rheumatoid" from infectious to biological or constitutional.
3. The emphasis on Stress and Strain by such authorities as Thorn, Selye, Reichstein and Hench.
4. The introduction of the 6 preparations:
   a. Cortisone—compound E
   b. ACTH
   c. Compound F
   d. Butazolidin (B-Z-D)
   e. Combinations of hormones such as testosterone
   f. Meticorten

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Kyphosis of the vertebral column may follow tetanus, with or without demonstrable fracture of the vertebral bodies. The force initiating this deformity was explained by Roberg on the basis of the contraction of certain muscle groups during tetanic convulsions. The majority of post-tetanic kyphoses occur in adolescents in an age group corresponding to that of juvenile kyphosis. The similarity to juvenile kyphosis includes clinical and roentgen characteristics of both conditions. Tetanic spinal deformity in adults is the result of a particularly severe and prolonged attack of tetanus. If the flexor muscles predominate, the thoracic kyphosis tends to increase under the action of the powerful abdominothoracic muscles. The lumbar and cervical sections of the spine enjoy ample articular mobility and can assume the position imposed by the contracting musculature without suffering any damage. But the thoracic section, particularly from the first to the ninth vertebrae, is nearly rigid and, when the greatest flexion obtainable is reached and the index of resistance of the bony tissue is exceeded, the muscular contracture produces a compression of the vertebral bodies. The damage occurs most frequently in the fourth to the sixth vertebrae because they represent the key of the thoracic vault and therefore the most exposed site.

The late deformities occur in adults and appear some time after the tetanus so that there is a silent interval between the disease and the vertebral symptomatology. The analogy with the Kummel-Verneuil syndrome is too evident to be overlooked. The intravenous administration of tolserol may be very effective.

and nervous disturbances General predisposing causes are fatigue, prolonged over-exertion, physical or mental strain, faulty body mechanics with resulting physiological disturbances, metabolic or endocrine disturbances, obesity, visceroptosis, imperfect or inadequate food, insufficient exercise, exposure to cold and infections Local predisposing causes are congenital defects, infections, occupational stresses and strains and trauma

Injuries and infections are often superimposed upon poor posture Trauma may be acute or continued, mild or severe One may consider trauma as the only factor, the precipitating factor or one which exaggerates a pre-existing abnormal condition

In considering infectious causes, the body may be divided into those parts above and those below, the clavicle Above the clavicle, are found the teeth, throat, sinuses, lymph nodes and thyroid gland The important structures below are (1) bronchi mediastinal nodes heart, (2) gastro-intestinal tract—lymph nodes, gall bladder, diverticula, (3) genito-urinary tract—urethra, Fallopian tubes, seminal vesicles and prostate

There are "touch-off" factors, precipitating causes, which produce the "explosion" Osler's analogy of the soil and seed in tuberculosis may be applied to arthritis of the spine The soil is the local and general condition of the patient the seed is the infective factor or precipitating cause

Predisposing factors are heredity, fatigue, poor posture while at work at play or during sleep worry anxiety, shock exposure to extremes of cold and dampness anemia and general poor health A large percentage of patients have given histories of overwork or of some emotional disturbance just prior to the onset of an attack Arthritis of the spine is found more commonly in persons past forty years of age Degenerative arthritis is the result of the "wear and tear" of increasing age and repeated trauma

Etiological Factors in Arthritis of the Spine

Hypertrophic changes are more common in heavy workers Chronic trauma that can produce arthritis may come from occupational trauma, or from postural defects scoliosis flat feet and obesity An injured joint is more vulnerable than a normal one, to infection

Arthritis tends to develop in persons who are chronically fatigued or chronically ill and who have experienced undesirable physical and mental hygiene for years Inadequate exercise, improper food and bowel hygiene, exposure to cold and dampness or rapid barometric fluctuations and infection are among the important factors Heredity body constitution and abnormal body build contribute to the development of arthritis of the spine

Two important considerations are trauma and endocrine disturbances

It is the consensus of the American Committee on Rheumatism that no simple infectious agent or any specific dietary deficiency or metabolic disturbance has been shown to be the cause of arthritis Any of these factors or certain combinations of them, under appropriate circumstances, may cause the disease

STEINBROCKER'S CLASSIFICATION

Classification	*Synonyms*
I Joint Disease of Unknown Etiology	
1 Rheumatoid Arthritis	*Atrophic arthritis* Infectious or infective arthritis Arthritis deformans Proliferative arthritis Primary progressive arthritis Focal arthritis Atrophic arthritis of the spine *Still's disease* Psoriatic arthritis
2 Osteoarthritis	Hypertrophic arthritis Degenerative arthritis Senile arthritis Malum coxae senilis
3 "Mixed Arthritis"	
4 Rheumatic fever	
II Joint Disease of Known Etiology	
1 *Specific Infectious Arthritis*	
a Gonorrheal	
b Tuberculous	
c Suppurative, etc	
2 Metabolic	
Gout	
3 Traumatic Arthritis	
4 Arthritis of Serum Sickness	
5 Neoplasms of Joints	
a Cyst sarcoma	
b Xanthoma hemangioma	
c Synovioma metastatic carcinoma	
6 Neuropathic Articular Diseases	
Tabes syringomyelia	
7 Hemophiliac Arthritis	
8 Pulmonary Osteoarthropathy	
9 Aseptic Bone Necrosis (?)	
III Nonarticular ("Rheumatic") Disorders	
1 Fibrositis	Myositis, myofascitis muscular rheumatism fascitis tendinitis fibromyositis, neuromyositis periarthritis, perineuritis, neuralgia, neuropathy
2 Neuritis	
3 Bursitis	
4 Synovitis	
5 Tenosynovitis	
6 Skeletal anomalies	
7 Postural defects	Static disturbances
8 The algias—myalgias, arthralgia, neuralgia, psychalgia, vasomotor instability, sympatheticotonia	

Etiological Factors —The causes of arthritis of the spine include infectious, metabolic, endocrine traumatic and miscellaneous factors The last named are heredity, age, occupation, allergic conditions visceroptosis, improper diet, abnormal mechanical strains and circulatory

Nervous System.—Organic or functional nervous symptoms are found in a large percentage of arthritis patients. Those with chronic arthritis of the spine and especially women, are apt to become morose or melancholic. Arthritis may attack a woman who has nursed a relative through a long illness. It is seen frequently in young women who have had a hysterectomy, and are otherwise perfectly healthy.

Traumatic Arthritis of the Vertebræ

Traumatic arthritis of the vertebræ is of great importance economically. It is the cause of many medico-legal battles, many of which are based on legitimate controversy. One must try to differentiate traumatic arthritis of the spine from trauma to an arthritic spine and trauma to the spine of an arthritic person.

Traumatic arthritis of the vertebræ is that type in which it seems plausible to attribute the pathological changes and therefore the symptoms and roentgen findings to a definite trauma. Trauma may be due to the occupation of the patient. A static abnormality may be the cause. The trauma may be due to indirect violence. Trauma may occur as one severe episode or multiple minimal incidents. In osteoarthritis trauma in the form of repeated minor injuries enters into the pathogenesis. Bone and joint structures make similar responses to unlike factors. Obesity is an important factor in hypertrophic arthritis. In order to admit causal relation between trauma and arthritis there must be definite evidence as to the time, place and degree.

Occupational Trauma.—Certain occupations and sports predispose to degenerative arthritis and this is particularly true of the spine. Keefer cites the brewery drayman who carries heavy loads on his shoulder producing a scoliosis with the convexity on the side opposite the shoulder which supports the greatest weight. Miners and farmers show changes more often than factory workers or mechanics who are employed in less arduous work. Women are affected less often than men.

Mechanical and Postural Factors.—Mechanical or postural disturbances such as abnormal weight-bearing due to weak, flat or rigid feet, cause static disturbances in the knee, hip and sacro-iliac joints or the lumbar spine predisposing to arthritis. Sway-back, knock-knees, bowlegs, internal derangements of the knee, Legg-Calvé-Perthes' lesion at the hip and congenital dislocation of the hip are disturbing factors.

Gynecological trauma may be caused by the strain superimposed upon the lumbar vertebræ by pregnancy which results in stretching of the ligaments of the sacro-iliac joint. Another type is seen in operative gynecology where a patient is placed on an operating table in a position of considerable mechanical disadvantage and distortion while long operations are being performed. The sway-back or exaggerated lumbar lordosis is a predisposing factor. High-heeled shoes have been criticized.

Because of their specialized function the intervertebral joints must function in spite of an enormous amount of physical injury. The weight-bearing joints especially are being constantly subjected to trauma. The most susceptible are the intervertebral joints of the lumbar spine, the

- Infection
  - Local
  - Focal
- Trauma
  - Without infection
  - Plus infection
- Toxins
  - Organic
    - Bacterial
    - Chemical
    - Tobacco
    - Drugs
  - Inorganic
    - Alcohol
    - Lead
    - Sugar
- Circulatory disturbances
  - Arteriosclerosis
  - Embolism
  - Hemorrhage
- Nutritional disturbances
- Mechanical strain
  - Knock knees
  - Bow legs
  - Flat feet
  - Weak musculature—poor posture
  - Weak ligamentous support
  - Loose bodies in joints
- Endocrine disturbances especially thyroid adrenals pituitary and gonads
- Nervous system disturbances
  - Central nervous system
    - Charcot s disease
    - Syringomyelia
    - Cord tumors
    - Peripheral nerve lesions
    - Brain tumor
    - Encephalitis
  - Sympathetic nervous system
- Allergic factors
  - Bacterial
    - Living
    - Dead
  - Chemical
    - Food
    - Plants
    - Animals
  - Physical
    - Heat
    - Cold
    - Moisture
- Climatic conditions
- Congenital defects
  - Bones of extremities
  - Spine
- Neoplasms

Lewin P J Am Dent Assn Feb 1932

Precipitating Factors —The direct or precipitating cause of an attack may be any acute infection trauma or an emotional shock In most cases of chronic arthritis the onset is initiated by infection, some form of trauma or strain or by the menopause Disturbances associated with infection may usually produce rheumatoid arthritis, those following trauma, strain or the menopause may cause osteo or rheumatoid arthritis

Environment May Play an Important Part —Juvenile arthritis may predispose to arthritis during adult life *Local circulatory disturbances are important* The local blood supply to the vertebral joint structure is the clue to pathological alteration The clinical benefits following therapeutic measures that improve the bloodflow, emphasize the importance of circulatory changes

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lumbosacral joint, the sacro iliac joints and the hips knees ankles and joints of the feet and hands The resulting damage is due to injury to the circulation of the joint structures If the cartilage of a normal joint is subjected to severe injury or to repeated mild trauma due to the incongruity of the joint surfaces or abnormal function, a condition similar to hyper trophic arthritis may develop Degenerative arthritis occurs in direct relation to the various factors that produce injury and excessive trauma

Various and sundry **manipulations** by unqualified persons may seriously injure ligaments and bone Improper carriage is a cause of foot, knee, hip and back strain Muscle strain from prolonged rest or activity in a strained position is an important traumatic factor Poor posture while sitting, standing walking and sleeping may produce arthritic pain In Charcot s arthropathy due to tabes dorsalis and other nerve lesions, continuous intra articular injury occurs because of the absence of pain sensation and by the incongruity of joint surfaces produced by incoordination of movements

In practically all of the spinal columns of 625 skeletons Willis found that hypertrophic changes were more marked in the lower lumbar segments and progressively less so from there upward The segments which are under the greatest mechanical stress present the highest degree of change

Epiphysitis of the vertebræ during childhood predisposes the individual to arthritis during adult life Arthritis may occur years after fractures into joints This emphasizes the importance of restoring the normal axial relationship of adjacent joints and all fractures into joints

Pathological Changes —Pathological changes may be found in the bones, joints, intervertebral disks, ligaments, muscles, nerves and blood vessels The chief bone changes are atrophic, with calcification and ossification of the soft tissues In atrophic or infectious arthritis of the vertebræ the pathological changes occur chiefly in the intervertebral articulations The degree to which these joints become painful or ankylosed determines the flexibility of the spine Exostoses are due to muscle and ligamentous pull and when present are nearly always found along the anterior spinal ligaments (I had one patient whose posterior cervical spinal ligament was completely calcified) The chronic ankylosing form of spondylitis begins in the small joints of the articular processes and leads to ankylosis The costovertebral articulations are often involved

Pathologico-Clinical Types —Spondylitis ankylopoietica was described by Connor in 1700 Fagge in 1877 described a similar case

Buckley adopts the classification of spondylitis in two main groups, spondylitis ankylopoietica or ankylosing spondylitis which includes both the von Bechterew type and Marie-Strumpell type and second, spondylitis osteoarthritica the degenerative or hypertrophic osteoarthritic form Wilkie designated the hypertrophic type as laborer s spine

The von Bechterew type is characterized by complete bony ankylosis of the spine with flattening of the lumbar spine the thoracic spine forming a smooth, round kyphosis, the curve of which is continuous with that of the cervical region The person loses the power to rotate his spine and when he wants to turn he is forced to turn his body entirely in order to look behind him

The Marie-Strumpell type is characterized by ankylosis of the spine and in addition ankylosis of the sacroiliacs

A contrast of two types of spondylitis deformans is given by Fraenkel is as follows

Von Bechterew Type	Marie Strümpell Type
Stiffening of the spine from above downwards	Stiffening of the spine from below upwards
The ankylosis results in a bent attitude, kyphosis is present	The ankylosis results in an erect attitude, kyphosis is seldom seen
Nerve root symptoms and irritation phenomena are present	Nerve manifestations may be absent in some cases
Joints of the extremities are not involved	The root joints of the extremities are involved and other small joints often ankylosed
Paretic condition of the muscles with slight atrophy	Atrophy of the musculature is often very pronounced
Process begins as an infection of the pia spinalis	Primary process is an ossification of the spine
Etiology heredity, trauma, syphilis	Etiology rheumatism and infection

The primary change may be near the intervertebral disks Exostoses are thrown out to support the weakened or strained joints If the osteophytes press on nerve roots, pain may be severe

Ankylosing spondylitis usually affects young men It is an ossifying fibrosis of the mesenchymal spinal system Deforming spondylosis attacks the working classes and affects the male sex less exclusively

Spondylitis osteo arthritica is more common in men The most important factor is strain and the wear and tear of heavy labor Roentgenograms reveal exostoses which require many months or years to form Because in many cases the condition became manifest after an injury this fact has an important medico-legal aspect In spondylitis osteo-arthritica pain is not a striking feature except following strain or over-use unless the exostoses press upon nerve trunks The primary change may be in the intervertebral disk which as a result of the long-continued strain upon its buffering function aggravated by toxic or infective influences undergoes degeneration or partial atrophy The exostoses serve to support the weakened articulation

Symptoms —Pain in the spine is often due to a lesion in the vertebral articulations It is an important cause of limitation of movement especially extension Technically they are the only spinal structures that can be affected by arthritis *Pain* may be constant or intermittent The stiffness and general disability of chronic vertebral arthritis are worse in the morning after parts involved have been at rest The three cardinal symptoms of static back disturbances are difficulty in getting up after rest or sitting (post-inertial dyskinesia) relief from pain when limbered up and renewed pain after prolonged activity Many patients complain of much pain while in bed and say they are relieved by getting out of bed and moving around This phenomenon has been explained variously (1) during inac-

tivity the circulation is at a lower level, which is improved by muscular activity, (2) during the rest in bed some of the ligaments, capsules, tendons and muscles relax, allowing movement of the affected joint, causing pain When activity is resumed, the muscles and ligaments become "set" and joint movement is restricted Pain during the night or after sleep may be due to the relaxation of muscles, so that sudden movements cause pain Some of the pain and stiffness after prolonged inactivity or unchanged *position is due to lowered circulation or contraction of elastic tissues both* of which are benefitted by massage, heat or moderate physical activity

Post-inertial dyskinesia is the term I applied to the pain or stiffness on resuming activity after a period of rest

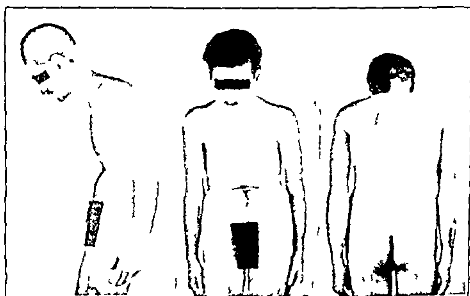


Fig 155 —Deformity in a patient with rheumatoid (atrophic) arthritis Note round back forward head compressed thorax and abdomen He suffered from pain rigidity and quick fatigue

Referred Pain —The referred pain of osteo-arthritis of the spine may simulate intercostal or abdominal pain gall bladder disease, appendicitis or kidney disease ureteral calculus or cardiac disease In thoracic involvement there is decreased chest expansion due to partial or complete ankylosis of the vertebræ and the ribs Disease of the lumbar lumbosacral or sacro iliac regions may cause symptomatic "sciatic neuritis" and sciatic scoliosis

Fatigue is one of the chief complaints of all arthritics and is evidenced by subnormal morning temperature, poor pulse, vasomotor instability, low blood pressure lowered metabolism and poor muscle tone Pemberton believed that fatigue was an evidence of toxemia or infection, "the patient was tired from fighting the infection"

Effects of Changes in Weather —Extremes of temperature and variations in humidity predispose to arthritis It is not so common in warm dry climates as in colder damper areas

Arthritic patients and their vertebral joints are sensitive to changes in barometric pressure which affect blood pressure and therefore the blood

supply Patients suffering from rheumatism claim they can prophesy the approach of bad weather they "feel it in their bones" Pemberton believes that exacerbations of rheumatoid disability following abrupt and striking weather changes were due to the inability of the arthritic to adapt his vasomotor circulatory mechanism, especially the capillary beds promptly enough to meet the changed demands

Deformities —The deformities of the vertebral bodies associated with osteoarthritis resemble those associated with senile and other forms of hypertrophic changes, but in this disease they are more extensive both in distribution and localization There is no tendency to fusion of the bodies directly, but they become united by the newly formed bone which bridges across the intervertebral spaces like stalactites and stalagmites

In osteo-arthritis of the spine pain usually follows the course of the spinal nerves and is often unilateral If there is a kyphos, it is usually long and rounded In tuberculosis, flexion of the spine increases pain and extension relieves it in osteoarthritis extension increases the pain, and flexion relieves it *Roentgenograms show atrophy, hypertrophy or both*

Nichols and Richardson presented an admirable monograph which is used as a standard for the pathological section of this chapter They divided joint lesions into those which arise from primary proliferative changes in the joints chiefly in the synovial membrane and in the perichondrium, and those which arise primarily as a degeneration of the joint cartilage

Types of Vertebral Arthritis —Two distinct clinical forms of vertebral *rheumatoid arthritis are recognized (1) the Marie-Strumpell type* beginning below and extending upward, described by Marie as spondylose rhizomelique, (2) the Bechterew type with kyphosis of the upper thoracic spine the process beginning above and extending downward The characteristic symptoms are pain in the spine radiating into the trunk or the extremities, stiffness gradually extending to all movements of the spine with a tendency to kyphosis and rigidity

The *Marie-Strumpell* type is characterized by ankylosis of the spine, hips and shoulder joints The Bechterew type is characterized by bony ankylosis of the spine with flattening of the lumbar spine, the thoracic spine forming a smooth round kyphosis the curve of which is continuous with that of the cervical region When the patient tries to turn his head, he is forced to turn his entire body

Spondylitis ankylopoietica begins as a synovitis of the intervertebral joints, with subsequent calcification of the ligamentous structure, followed by rigidity of the spine

Spondylitis ankylopoietica produces complete ossification or ankylosis of the small vertebral joints and ossification of the anterior longitudinal ligament (resembling a bamboo stick) without any marginal dents or scrolls In extensive spondylosis deformans if several consecutive vertebræ show marginal scrolls with a smooth surface spanning the intervertebral space like a bridge, one might diagnose Bechterew's disease, but if the small vertebral joints show an open articular space, the diagnosis of spondylosis deformans is established

Bechterew summarized the specific type of spondylitis which bears his name, as follows (1) location primarily in the spine (2) an hereditary factor (3) history of trauma (4) sudden onset, (5) pain diminished

sensibility, paresthesia, often twitchings, (6) paretic condition of certain muscles, (7) possibly involvement of hips and shoulders to a minor degree (8) limited kyphosis and ankylosis, (9) neurological abnormality shown at necropsy, (10) rigidity and kyphosis, (11) kyphosis leading to atrophy of the disks

Marie enlarging on Strumpell's earlier observation described the type of spondylitis which he designated as 'spondylose rhizomelique" which also involves the "roots of the extremities It is characterized by (1) involvement beginning in the hips or lumbar spine and ascending to involve the shoulders, (2) absence of paresthesia or hyperesthesia (3) limitation of pain, to the spine hip and shoulder joints, (4) no involvement of the other joints (5) being usually infectious in origin

With complete bony ankylosis of the spine, a patient has no rotation and consequently has to turn his whole body if he wishes to look behind him With Marie-Strumpell disease in which ankylosis of the hips and shoulder joints occurs, the patient has difficulty in maintaining his balance when standing without support

In Swaim s series the typical rounded ' bamboo ' spine was produced by ossification of the ligaments, leaving the intervertebral spaces intact Most of his patients complained of stiffness in bending or pain in the ribs on breathing or on moving At first the stiffness is due to prolonged muscle spasm of all the spinal and abdominal muscles, which are held rigid The pain on motion is so severe that this constant protection apparently is necessary for relief Ultimately this pain subsides as either the inflammation disappears or ossification of the ligaments takes place, so that motion no longer produces irritation Muscle spasm may exist for some years before actual ossification takes place The ribs became fused at their articulations so that chest motion was sometimes completely lost The sacro-iliac joints were fused early in all the cases After fusion was complete, the process stopped In some cases the hips became fused also

Symptoms and Signs of Arthritis of the Vertebræ

Arthritis of the vertebræ produces local and referred pain limitation of motion a stiff spine tenderness to movements sensitiveness to jarring and in some cases pain on sneezing coughing or straining at stool

When arthritis of the spine produces referred pain it is called radiculitis Irritation of the nerves may be due to an inflammatory exudate in the intervertebral foramina or in the epidural space causing pressure on the spinal nerves or their roots

The significant factors in the history of a patient with arthritis of the spine are age heredity previous illnesses injuries static defects exposure metabolic disturbances poor bowel elimination allergic predisposition endocrine disturbances circulatory lesions psychological factors dietary habits and obesity

A history of nervous shock sometimes from fright or grief is more common among women than men A lower threshold of nervous stability permits the mental and physical hardships of life to affect some persons more than others Injuries exposure to extremes of temperature and moisture, also metabolic disturbances are frequently described

ARTHRITIS HISTORY SHEET

NAME AGE SEX DATE

1 *Complaint,*

Chief presenting symptoms

Pain
- Location—local—referred
- Character
- Affected by
  - activity
  - rest
  - change of weather
  - treatment

Stiffness—segmental rigidity
Limitation of motion
Swelling
Crepitus
Weakness
Fatigue
Change of weather
Atrophy
Deformity
Nervous symptoms
Mental symptoms
Circulatory symptoms

2 *Duration of symptoms*

Early Recent Onset

3 *Patient's own conception of the cause of trouble,*

Heredity
Infection
Injury
Exposure
Occupation
Diet
Endocrines
Change in weight

4 *Progress*

Is patient improving? To what is improvement due?
Is patient getting worse? To what is this due?

5 *Previous treatment*

Treatment	*Apparent Effect*
Rest	
Heat	
Massage	
Diathermy or Inductothermy	
U–V Lamp	
Diet	
Medicine	
Glandular Therapy	
Vaccines	
Mineral Baths	
Other Baths	
Traction	
Splints	
Manipulation	
Posture Work	

6 *General health*

Up to par?
Teeth?
Throat?
Sinuses?
Respiratory tract?
Gastro intestinal tract?
Genito urinary tract?
Skin?
Glands?
Weight?
Height?

7 *Habits*

Work
Play
Diet: meat, fish, eggs, sweets, cereal, carbohydrates; coffee, "cola" products, chocolate, tea
Smoking
Liquor

8 *Previous illnesses and injuries*

Age Period	*Illness*	*Injury*
Infancy		
Childhood		
Adolescence		
Early adult		
Late adult		

9 *Heredity*

Rheumatism
Gout
Constipation
Tonsil infections
Cardiac lesion
Renal lesion
Diabetes

10 *Sexual history*

Menstruation
Married
Children
Menopause

Physical Findings in Vertebral Arthritis —The physical signs in arthritis of the spine are limitation of movement impairment of function, muscular spasm, tenderness and later such deformities due to structural joint changes and soft tissue contractures as an exaggerated round back with increased lumbar lordosis or a flat back There is usually a kyphosis, although some spinal columns become rigid in the straight position

Deformities —The most common deformity is a well rounded kyphos This is usually a slowly progressive change which is very resistant to control or improvement The next most common physical change is the establishment of a straight back with obliteration of the normal curves The hypertrophic person is predisposed to a rounded back the rheumatoid individual

PHYSICAL FINDINGS OF ARTHRITIC PATIENTS

General examination

- Appearance
- Regional
  - Back
  - Extremities
  - Neck
  - Jaw
- By systems
  - Throat, nose, sinuses, ears
  - Eyes
  - Mouth
  - Respiratory system
  - Circulatory system
    - Central
    - Peripheral
    - Sympathetic
  - Gastro-intestinal tract
  - Genito-urinary tract
  - Glands { Regional—lymphatic / Endocrine }
  - Skin
  - Muscles
  - Bones
  - Joints
- Stiffness
- Limitation of motion—pain
- Swelling
- Crepitus
  - audible   coarse
  - palpable   fine
- Heberden's nodes
- Haygarth's nodosities
- Atrophy
- Blood pressure
- Skin sensitization tests

is destined to have either a rounded or a straight back The causes of deformity of the back are pain, muscle spasm, incorrect posture, unequal muscle pull, fibrositis, myositis and capsulitis Muscle spasm is the initial factor and may be progressive because of the overaction of the stronger muscles Most of the deformities are preventable, proving the statement, "The price too often paid for comfort during the acute stage is that of becoming a cripple for life"

Limitation of movement may be due to joint deformity, soft tissue contraction and contractures pain, atrophy, muscle weakness, and bony union

Blood Pressure—Chronic arthritics usually have low blood pressures The blood pressure is usually higher in the hypertrophic cases than in the rheumatoids

Changes in the Skin and Nails—Skin changes in arthritis may be due to circulatory, neurogenic, endocrine disturbances and barometric variations

Circulation—There is evidence to support the association of defective circulation with the rheumatic syndrome The sensitivity of persons with arthritis and fibrositis toward climatic change is traditional

Characteristics of a Patient with Atrophic Arthritis of the Spine —The patient with rheumatoid arthritis of the spine is often an underweight man whose back has limited movements and is sensitive to motion The chief complaint is pain and stiffness of the joints and a constant sense of fatigue Posture is usually poor The affected intervertebral joints usually become fixed producing a deformity The sedimentation rate of the erythrocytes in rheumatoid arthritis parallels the severity and extent of the arthritic process

Basic Roentgenographic Changes in Vertebral Arthritis

Changes in { Density / Shape
Atrophy
Hypertrophy
Sclerosis
Absorption
Calcification in soft tissues
Ossification of soft tissues

Roentgenographic Changes in Various Parts of Each Vertebra

Alignment
Size
Shape
Parallelism of vertebral borders
Size of intervertebral disks
Shape of intervertebral disks
Density of intervertebral disks
Vertebral body
Foramina
Facets

Characteristics of a Patient with Hypertrophic Arthritis of the Spine —The person with degenerative arthritis of the spine is usually large often obese and plethoric The joints are moderately tender or sensitive Extremes of motion produce severe pain

Roentgen-ray Findings in Arthritis of the Spine —Roentgenography reveals atrophic or hypertrophic changes The important findings are variations in density and changes in the shape of bone with atrophy and proliferation of bone increased density and calcification or ossification of soft tissues The two chief findings are (1) atrophy of bone (2) hypertrophy Atrophy is shown by decalcification Hypertrophic changes are indicated by increase in bone formation usually at the osteocartilaginous margins and at the attachments of ligaments

The characteristic roentgenographic changes in osteoarthritis are lipping, excrescences, bridging, irregularities, slight changes in shape, spreading, broadening and sclerosis of edges. The characteristic changes in rheumatoid arthritis are decalcification and "pencilling" of vertebral borders. The intervertebral joints are affected early and when fusion occurs, movement of that segment is lost forever. Both hypertrophic and atrophic changes may occur in the same vertebra.

Oppenheimer uses the name vertebral epiphysis to designate the articulation between two vertebral bodies and the interposed disk. He calls attention to the fact that this juncture is a synchondrosis or symphysis, like that at the pubes.

The apophyseal joint, which connects contiguous articular processes, is a synovial or diarthrodial articulation like the joints of the extremities.



Fig 156.—Antero posterior projection of lumbar vertebræ of a patient with hypertrophic arthritis (osteo arthritis). Note inter and intra vertebral bridging of bone, narrowing of intervertebral spaces (especially L4 and L5). Complete disappearance of intervertebral articulations and some calcinosis intervertebralis. This patient had passed through the painful stage and had reached the stage of complete rigidity.

A person with the *infectious* type of arthritis may metabolize his bone salts well, the patient with the atrophic type either does not get bone salts or is unable to deposit them in his bones. In the atrophic type there is absorption of lime salts and, therefore, increased radiability of the bone. This condition may progress to the point where the cortex and the bone look as though someone had gone over their margins with a steel engraver's instrument.

In the hypertrophic type there may be an increase in the lime salts in the bone, and therefore decreased radiability. Osteophytes, lipping or osteocartilaginous changes are characteristic. The osteophytes may become large and in bridging the vertebræ, resemble stalactites and stalagmites. There are fusion and ankylosis in the advanced stages so that the spine presents the picture of the ankylosed Marie-Strumpell type.

It must be emphasized that no single roentgenological feature is a diagnostic criterion for any one type of chronic arthritis.

Roentgen findings include atrophic and hypertrophic changes and a combination of the two. One should look for changes in the bodies and

edges of the vertebræ, in the articular facets and in the intervertebral foramina

In hypertrophic arthritis, Barker described the process as beginning in the intervertebral disks, there are marked exostoses in the bodies of the vertebræ and especially "lipping" of the bodies at the edge of the inter vertebral disks, often with a few clasplike formations extending from one vertebra to another, but never so extensively as in the ankylosing forms The small joints between the articular processes do not undergo intra capsular ankylosis in this disease, though motion may be limited by exos toses

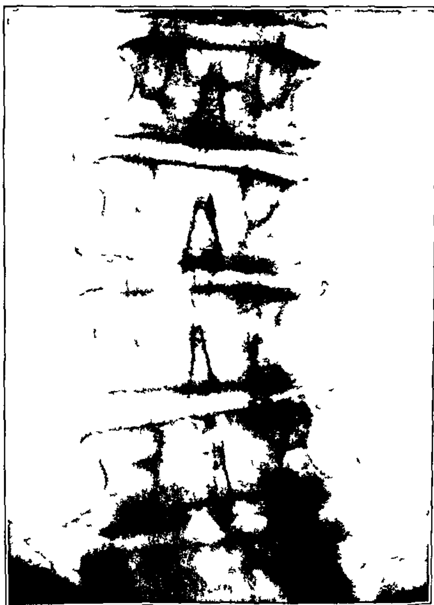


Fig 157 —Vertebral arthritis Note disparallelism of vertebral borders narrowing of several intervertebral spaces platyspondylia osteophytes hooks spurs and disappearance of intervertebral joints (This condition corresponds with Oppenheimer s discogenetic hypertrophic spondylitis)

Exostoses are more pronounced where pressure is a prominent feature. Bony changes are more pronounced on the anterior surfaces of the spinal column and on the concave side of a scoliotic spine. Ankylosing spondylosis is characterized by atrophy or decalcification of the vertebral bodies. Ossification of the anterior longitudinal ligament is the primary vertebral change in some cases.

Laboratory Examinations and Findings in Vertebral Arthritis.—The chief laboratory examinations that should be made are the following:

Foci of Infection.—Nose, sinuses, throat, teeth, sputum, genito urinary tract.

Urine.—Chemical—cytological—bacteriological.

Blood.—Chemical—cytological—sedimentation rate.

Feces.—Mechanical, chemical and bacteriological.

Perspiration.—Reaction.

Metabolism.—Basal rate.

Bacteriological examination of regional lymph nodes.

In hypertrophic cases the metabolic rate is usually below normal, whereas in rheumatoid cases it is usually above.

Blood.—Blood examinations consist of red and white cell counts, hemoglobin and differential count. The chemical blood examination consists of determinations of sugar, uric acid, urea nitrogen, non-protein nitrogen, creatinin, cholesterol, chlorides, plasma, CO_2, calcium and phosphorus. Leukocytosis of moderate degree is common. Hemoglobin determinations reveal anemia in atrophic cases.

Sedimentation Test.—In active cases of rheumatoid arthritis the sedimentation rate of the red blood cells is greatly elevated, attaining values exceeding 30 mm. in one hour. It usually parallels the severity and extent of the arthritic process. In cases of osteoarthritis, on the other hand, the sedimentation rate rarely attains values greater than 30 mm.

Short, Dienes and Bauer find that the sedimentation rate is the most useful laboratory test thus far in common use to aid in the recognition and evaluation of patients with active rheumatoid arthritis.

Hartung and Bruger found that the cholesterol content of the plasma is decreased in rheumatoid arthritis and increased in osteoarthritis.

Urine.—The chief examinations of the urine concern uric acid, acetone, diacetic acid and indican.

Stools.—Examination of the stools may afford valuable information, especially for the bacteriology, metabolic studies and parasitology involved.

Bacteriological Examination of Various Regions, Secretions and Excretions.—Bacteriological examinations of the teeth, throat, nose, pharynx, sinuses, ear, sputum and genito urinary tract secretions should be made.

Blood Chemistry.—The blood sugar level remains elevated as long as infection is present.

Diagnosis.—The diagnosis of arthritis of the spine is based upon the history, physical examination and the roentgen ray findings. One must remember that a person with arthritis may have another lesion such as metastatic carcinoma of the spine.

One must determine the following:

I Does the patient have arthritis?
II Is there any other lesion present such as
- Disk lesion
- Tuberculosis
- Neoplasm
- Malignancy
- Metabolic
- Endocrine disturbance
- Old trauma

Differential Diagnosis*

	Rheumatoid spondylitis	**Degenerative spinal joint disease** (*osteo- or hypertrophic arthritis*)
Sex	Males 10 1	Either sex
Age incidence	Usually begins from 20 to 40 years	Symptoms uncommon before 45 years
Sedimentation rate	Markedly elevated	Normal, in uncomplicated cases
Main symptoms	Pain stiffness of back, tenderness over involved joints	Pain in back root pains, areas of anesthesia and paresthesia occasional spasm of vertical muscles
Rigidity of thoracic cage	A striking symptom	Absent
Constitutional symptoms (loss of weight strength and muscle tone slight fever tachycardia)	Usually marked	Absent in uncomplicated cases
Marked *restriction of* spinal motion especially in lumbar and dorsal regions	Present	May be slight
Intervertebral spaces	Normal	Usually narrowed
Osteophytes	Usually none	May be marked
Narrowing of sacro-iliac joints	Characteristic	May occur in some cases
Narrowing of small posterior intervertebral joints	Characteristic	Absent (except to a slight extent in occasional cases)
Bony ankylosis of the sacro iliac joints and spinal posterior intervertebral joint	Characteristic late in disease	Absent
Calcification of longitudinal ligaments	A late characteristic	Absent
Results of roentgen therapy	Excellent in early cases definite benefits even in later cases	Subjective improvement in some cases but no dramatic results as in rheumatoid spondylitis

* Comroe

In the differential diagnosis one should consider tuberculosis inflammatory rheumatism neuritis myositis fibrositis bursitis tendinitis myofascitis infectious diseases syphilis gout, osteomalacia, and neoplasms

In the differential diagnosis between tuberculosis and osteoarthritis of the thoracic spine important differential points are the following Tuberculosis is more commonly found in the young child or young adult, arthritis in individuals usually past forty years The onset of arthritis is usually more insidious Flexion of the spine increases and extension relieves the pain in tuberculosis, the opposite being true in arthritis The presence of an abscess makes the diagnosis of tuberculosis very probable Local and referred pain may be identical in the two diseases In arthritis, remissions are common The kyphos of tuberculosis is more angular Spinal cord symptoms are more common in tuberculosis owing to the presence of an exudate Radiculitis is more common in arthritis Antero posterior stereoscopic and lateral roentgenograms supply valuable information If the breathing is wholly abdominal owing to ankylosis of the costovertebral articulations or to the general approximation of the origin and insertion of the accessory respiratory muscles from kyphosis or from stiffness of the midthoracic spine or if the disease occurs in young persons under forty it is almost certainly chronic ankylosing spondylitis

The spine is more uniformly involved throughout its whole length in the ankylosing type than in spondylitis deformans Roentgenograms are decisive in most cases In spondylitis deformans the early bone changes may be marked and the clinical symptoms slight while in the ankylosing spondylitis severe clinical symptoms may precede demonstrable bone and joint changes by a year or more

Prognosis—Hench says that "arthritis may be as inconsequential as gray hairs or more agonizing than death"

The prognosis is highly variable, but never favorable The outlook depends upon the type of arthritis present the age of the person, the presence of an hereditary predisposition activity of a focus of infection and its early discovery the duration of the attack, the economic situation of the person affected and the opportunity of obtaining proper treatment

There are very few persons with arthritis who cannot be benefited usually most persons can be markedly relieved In an advanced case the patient should be plainly told that he can be relieved of much of his pain and that some of his stiffness and deformities can be corrected Joint mobility can be increased in the majority of cases Everything possible should be done to prevent deformity

Factors which determine the prognosis are the age resistance and general health of the patient duration of the condition the plan of treatment and the cooperation of patient and physician Unfavorable factors include heredity youth, poor general condition, long duration of the disease activity of the disease atrophy, unknown allergic reactions repeated infections occupational trauma and neurogenic and psychogenic reactions The earlier the disease is recognized and treatment begun, the better the prospect of cure High-strung nervous patients do badly Smith described a type of chronic arthritis that is highly resistant to treatment the psychic type found in maiden school teachers, and patients with bad home environments and no money

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The prognosis should be guarded because of the difficulty in determining the active cause of the disease and because of the failure of regeneration in a damaged joint Permanent bony changes, however, do not preclude the possibility of relief from symptoms When arthritis is recent and destructive changes of bone are not extensive complete functional restoration may be expected If the cartilage has not been destroyed, a return of satisfactory function can be anticipated

Relapses —Reutschler, VanZant and Rowntree believe that the precipitation of relapse by such phenomena as the proximity of storms and rainy or cold weather represents a failure of the sympathetic nervous system in adapting the patient to his environment

The relation of diet to relapses was variable Idiosyncrasy for specific foods was more important than the size or general type of meal eaten Allergic phenomena must be considered a possible explanation for this fact Respiratory infections are frequent precipitants of relapse Women more often experience aggravation of signs and symptoms during their menstrual periods Circulatory and metabolic changes with increase of nervous irritability complicate the menstrual period and predispose to relapse During pregnancy the tendency is toward improvement

Inactivity promotes circulatory lag and suboxidation in the tissues Atrophy and deformity resulting from disuse must be opposed to the point of the patient s tolerance Coates said "A movement a day keeps adhesions away

Strict observance of Ghrist and Hench s rules for behavior should minimize the incidence of relapse and be of considerable benefit in smoothing the course of the condition (1) avoid physical excess and find and maintain the limit of tolerance (2) control constipation by corrective diet (3) avoid foods which aggravate the condition, (4) avoid worry and shocks, optimism is imperative (5) avoid postural difficulties use comfortable chairs and beds but alternate rest with periods of activity, (6) avoid climatic alterations by proper clothing, heating and ventilation on exposure change clothing after a warm bath In a cold climate use physical therapy and contrast baths to increase tolerance to temperature changes, if necessary change climate (7) increase general resistance by adequate sleep food sunshine and exercise

Course —The course of arthritis of the spine may be extremely variable There are recurrences recrudescences and remissions

Treatment of Vertebral Arthritis

The treatment of any patient with arthritis of the spine may be divided into three parts local focal and general Before one undertakes the treatment of a person with arthritis of the spine he must consider (1) the causes, (2) the mechanics involved (3) the type of arthritis (4) the prophylactic measures (5) the appropriate treatment The case management must consider removal of the cause improvement of the general condition of the patient and enhancement of resistance to the etiological factors by good personal hygiene, including proper foods sunshine, physical therapy, a cheerful environment, and a number of other measures

The most important factor is the relief from pain. This should be done while a thorough search for the etiological factors is being made. The spine must be placed at physiological rest. The patient should be put to bed and local treatment instituted.

Non-operative treatment includes recumbency in bed, the use of a Bradford or Whitman frame, a rigid mattress, head traction and pelvic traction, plaster of Paris casts or shells, and braces. Physical therapy includes heat, gentle massage, diathermy and general constitutional treatment. Posture

Indications for Treatment

I. Improve constitutional factors
II. Eradication of foci of infection
III. Relieve pain
IV. Prevent deformity
V. Correct deformity

The Places Where Treatment Can Be Given

I. Office
II. Home
III. Hospital
IV. Special centers—spas

Outline of Treatment of Vertebral Arthritis

Rest—imperative, frequent
General constitutional treatment
Put patient in state of optimal health
Eradicate foci of infection (defocalization)
Correct static and postural defects (pelvis, legs, feet)
Regulation of metabolism
Optimal diet
Control of weight (obesity, leanness)
Control of constipation
Relief from worry
Special nursing care
Improvement of circulation, general, local
Physical therapy—heat, massage, baths, inductotherm, paraffin, hyperpyrexia—electric blanket for sleep, ultraviolet radiation, special baths
Protection against unfavorable elements, during day, during night
Support—belts, corsets, braces, casts
Optimal climate for comfort
Medicines for pain—salicylates, bee stings, compounds E and F, ACTH, Butazolidin, Metacortin
Medicines for general health, sleep, calcium—iron—arsenic, sulfur, glycocoll—benzedrine sulfate, endocrine gland products (thyroid, gonads, adrenals)
Vitamins—by mouth, by injection, routine, specific (B_1, B_2, D)
Vaccines—autogenous—specific (combined with Vitamin B_1)
Blood transfusion
Radiation therapy, roentgen ray, radium
Manipulative therapy
Surgery

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During the acute stage of all forms of vertebral arthritis when pain tenderness, swelling and limited movement are present the most important indications are for rest relief from pain and protection against deformity In this stage, the back should never be allowed to remain in a strained position during rest or activity Painless active movements are encouraged After the acute stage has passed joint function should be restored The best results follow daily rest periods graduated exercises and physical therapy

Internal Medication —During the acute episode salicylates are of value They may be administered by mouth (10 to 15 *grains of sodium salicylate* three times a day), or by rectum (30 grains of powdered sodium salicylate dissolved in 2 ounces of warm tap water as a retention enema) Rectal administration gives quicker relief than oral without gastric irritation

Vitamin B in large doses is of some value during the acute stage After the acute stage is passed maintenance doses of vitamin B can be given intramuscularly or by mouth

There are various kinds of **injections** that have been proposed for backache Each authority aims at his own favorite anatomical structure The substances used are normal salt solution quinine and urea novocaine and atropine The various anatomical structures that are infiltrated are nerves ligaments, and muscles The chief ligaments injected are the lumbosacral Various muscles *i e*, the erector spinae are often relieved by injection

The following agents have been found to be effective The salicylates Compound E, Compound F ACTH, Butazolidin (B Z-D), Metacortin

The oral administration of Cortogen provides a rapid cortisone effect

Vitamin B_1 (per os hypo, I V) Vitamin B_{12}, Nicotinamide, Calcium

Intravenous—B_1, Nicotinamide Salicylates

Salicylates per rectum

Ammonium Chloride—7½ gr t i d

Pabirin, a combination of salicylate para-amino benzoic acid and ascorbic acid gives the arthritis patient relief of discomfort with a minimum of side actions

Hermann considered mephenesin effective only if it relieved aching pain and improved key joint motion beyond 15 degrees by the end of one week of treatment Gauged by this standard 153 (76 5 per cent) of his 200 patients treated, benefited by its use It was the acute rather than the chronic conditions which responded best In rheumatoid spondylitis however the benefit was striking An occasional patient who did not respond well to mephenesin alone was given mephenesin in the usual dosage supplemented with glutamic acid hydrochloride 5 or 10 gr initially plus 5 or 10 gr before lunch and dinner (This subject is elaborated on in the chapter on Disk Derangements)

Medicinal Treatment —During the stage of acute pain the salicylates are helpful They stimulate capillary circulation I often prescribe four to ten doses of 30 to 60 grains of sodium salicylate in 2 or 3 ounces of warm tap water per rectum every three to four hours Sodium iodide is used, intravenously, alone *or in combination* with sodium salicylate and colchicum Compounds E and F, ACTH and butazolidin are usually very effective

Sodium gentisate is a safe, and effective analgesic for the relief of mild and moderately severe pain

exercises are important in certain cases The Taylor spine brace or the Goldthwait brace are valuable The newer types are those of Baker and Jewett

Lewin's Anodyne Lotion in the Treatment of Spinal Arthritis —The routine treatment consists of the application of an anodyne lotion and fomentations This is continued from 9 A M until 9 P M except for daily physical therapy massage, heat, inductotherm and hot paraffin dips

My modification of Porter's lotion is as follows

℞—Tinct opii	30
Liq plumbi subacet dil	40
Phenolis 0 5 per cent	50
Ext hamamelidis	60
M et ft lotio	
Sig —Externally as directed Shake printed on label	

The technic during the application follows The patient lies on his face with his feet hanging over the foot of the mattress

COMPARTMENT I
1 Apply 4 layers of gauze over the entire area
2 Saturate the gauze with the well shaken lotion
3 Apply oiled muslin, oiled silk, or rubber sheeting

COMPARTMENT II
4 Apply flannel or wool wrung out of hot water
5 Apply oiled muslin, oiled silk, or rubber sheeting
6 Add hot water bottles

COMPARTMENT III
7 Cover all with Turkish towels
8 Refill the hot water bottles every two or three hours

REMARKS
9 Add lotion three times daily from 9 A M until 9 P M
10 From 9 P M until 9 A M use an anodyne ointment plus dry heat and woolen or flannel coverings

Treatment includes rest proper bed posture, immobilization, traction, local applications, injections physical therapy support and manipulation The following measures are beneficial rest in bed on a semirigid mattress and the application of traction followed by some form of support or immobilization

The person with a rheumatic back should be put to bed in a recumbent position either on a rigid mattress or on a Bradford Whitman or Herzmark frame Head traction or pelvic traction should be applied Plaster of Paris casts or shells and braces and physical therapy should be provided The Taylor spine brace or the Goldthwait brace may be used as support Manipulation is occasionally indicated but the cases must be carefully selected and the manipulation carried out cautiously Operations on the bones include decompression and stabilization procedures Operations on the nerves include sympathectomy rhizotomy and cordotomy

Treatment includes such supports for the back as strappings belts corsets and spine braces As a therapeutic test, adhesive strapping should be tried If relief is obtained a support should be made If no relief follows hospital treatment is indicated This includes traction Local treatment consists of radiant heat diathermy or inductotherm and massage A plaster of Paris cast provides immobilization in selected cases and should be followed by a spine brace

During the acute stage of all forms of vertebral arthritis when pain, tenderness, swelling and limited movement are present, the most important indications are for rest, relief from pain and protection against deformity. In this stage, the back should never be allowed to remain in a strained position during rest or activity. Painless active movements are encouraged. After the acute stage has passed, joint function should be restored. The best results follow daily rest periods, graduated exercises and physical therapy.

Internal Medication.—During the acute episode salicylates are of value. They may be administered by mouth (10 to 15 grains of sodium salicylate three times a day), or by rectum (30 grains of powdered sodium salicylate dissolved in 2 ounces of warm tap water as a retention enema). Rectal administration gives quicker relief than oral without gastric irritation.

Vitamin B in large doses is of some value during the acute stage. After the acute stage is passed, maintenance doses of vitamin B can be given intramuscularly or by mouth.

There are various kinds of **injections** that have been proposed for backache. Each authority aims at his own favorite anatomical structure. The substances used are normal salt solution, quinine and urea, novocaine and atropine. The various anatomical structures that are infiltrated are nerves, ligaments and muscles. The chief ligaments injected are the lumbosacral. Various muscles, i.e., the erector spinae, are often relieved by injection.

The following agents have been found to be effective: The salicylates, Compound E, Compound F, ACTH, Butazolidin (B.Z.-D), Metacortin.

The oral administration of Cortogen provides a rapid cortisone effect.

Vitamin B_1 (per os, hypo, I.V.) Vitamin B_1, Nicotinamide, Calcium.

Intravenous.—B_1, Nicotinamide, Salicylates.

Salicylates per rectum.

Ammonium Chloride.—7½ gr. t.i.d.

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Vaccine Therapy.—Vaccines are the specific, nonspecific, autogenous and stock varieties. Vaccines may be made from any infected focus, including the regional lymph nodes.

Protein Shock Treatment.—Draper suggests that the good effects of bees' stings in rheumatoid arthritis are due to protein shock therapy, which depends on the occurrence of a febrile reaction for twenty-four to forty-eight hours, and is often accompanied by exacerbations of the arthritis.

Hemotherapy—Blood Transfusions.—The value of whole blood from a robust person is of value especially in atrophic cases. Autoserotherapy consisting of the patient's own serum injected intramuscularly has been recommended. Autohemotherapy or the injection of whole blood has also been used.

Postpartum Plasma.—Pooled postpartum plasma produced a gradual and sustained remission in rheumatoid arthritis according to Grammer. Remissions were observed to last from six weeks to one and one-half years. Patients gained up to five pounds in weight. An improved sense of well-being, a better appetite, increased vigor, strength, and amelioration of joint pain and swelling were routinely observed. In more than 500 postpartum plasma treatments there were no instances of homologous serum hepatitis. It produced no side effects.

Climatotherapy.—Natural heat is of value during the painful stage of arthritis. The best known American places are Phoenix and Tucson, Arizona; Albuquerque, Santa Fe and Las Vegas, New Mexico, and Palm Springs, California.

The treatment must be directed toward the removal of all sources of continued irritation. These include mechanical strains, focal infection, intoxications and absorptions.

The bed springs should be semirigid. Sponge rubber mattresses are helpful. When the muscles have relaxed and the sensitiveness has largely disappeared and the range of painless movement has greatly increased, a period of immobilization is prescribed. This is accomplished by a plaster-of-Paris cast or a brace.

The body cast extends from the axillæ to the great trochanters and is applied with the patient in the most comfortable position he can assume. If the cervical spine or any of the upper nine thoracic vertebræ are involved, the cast should come up under the chin and occiput. The patient sits on a stool with head traction exerted on the chin and occiput, while the cast is being applied.

The plaster cast is worn for from one to four weeks, depending on the duration of the disease and the patient's comfort. If the back is still sensitive, another is applied; if not, a brace is made.

Diet.—Bauer says "there is no special diet for arthritis but there is an optimal diet for every person with arthritis."

The main types of metabolic arthritics are: (1) those who are overweight; (2) those who are underweight; (3) those who have a gouty diathesis; (4) the diabetic. In the overweight individual one should cut down the entire food intake, reduce the intake of carbohydrates and fats, prescribe glandular therapy, outline exercises and control constipation. In the underweight individual one should force feeding, balance the ration, prescribe an

anemia diet, rest, cod liver oil, irradiated foods and above all beware of depleting diets. In the gouty person one must emphasize a low purine diet, sweat baths and exercise. In the diabetic there is a definite diet in addition to injections of insulin or protamin insulin. Those of the asthenic group do better on a generous diet. Muscle tone must be maintained. The end products of decomposition of animal proteins are harmful to patients suffering from hypertrophic arthritis.

The late Cardinal Gibbons remarked that he "owed his good health to his bad digestion." If there were more dyspeptics there would be fewer arthritics.

Mineral Waters.—Mineral waters such as Kalak, Mountain Valley and Gerolsteiner are recommended. A pleasant combination is to add the juice of half an orange or one third of a lemon to 6 ounces of carbonated water.

Allergy.—If allergy is an important factor in arthritis it behooves the medical profession to recognize and treat the allergic child, because the allergic child of today is the precursor of the allergic adult.

Hygiene.—Fresh air, sunshine, change of residence and occupation, minimizing exposure to sudden alternations of heat and cold and the avoidance of chilling, are important. Proper underclothing is an important factor.

Much harm can be done by producing anemia and asthenia and in disturbing the nervous mechanism by too rigid restrictions in diet. The person with arthritis has a battle to fight and food is his most important source of ammunition.

The newer drugs, Compound E and F, ACTH, Meticortin and Butazolidin are the most potent agents we have found to combat these diseases.

The daily administration of cortisone (Compound E) or ACTH leads to dramatic improvement in most cases of rheumatoid arthritis. It gives disabled individuals a chance to live and work by relieving pain, swelling and discomfort. They feel better, eat better and usually regain lost weight.

The main drawback is that the symptoms are likely to return when the administration of the drugs is discontinued.

ACTH and cortisone are active hormones and as such are capable of producing symptoms of their own. The substances alter sodium and potassium metabolism, but by checking the intake and output twice a week and insisting on daily weighing, the problems associated with edema or sodium retention are avoided. The moon-shaped face, hirsutism, beginning acne, loss of scalp hair and pigmentation of the nails and skin are typical findings. Now and then diabetes mellitus occurs. Euphoria approaches the stage of hypermania. A definite depression may follow.

More serious reactions may follow the long continued administration of these hormones. ACTH, for example, produces hypertrophy of the adrenal cortex with all the signs of hyperadrenalism. The continued use of cortisone has the opposite effect, producing atrophy of the adrenal gland. These occurrences were anticipated inasmuch as ACTH stimulates the adrenal and Cortisone may be considered replacement therapy.

ACTH and Cortisone must be used cautiously in treating active infections. There is some evidence that they suppress antibody formation.

Cortisone and ACTH will extend the use of physical measures in treatment of patients with rheumatoid arthritis Hormonal therapy opens the way for restoration of a self-dependent status to otherwise incapacitated persons The "wonder drugs permit surgery on certain cases that would be considered too risky to operate otherwise

The process of rheumatoid arthritis must be distinguished from that of irreversible articular damage Adrenal and pituitary hormones influence the active disease, but are not effective in reversing all the anatomic changes

In discussing irreversible changes Ward emphasized that Cortisone may inhibit the active inflammatory response of tissue but it does not repair damage already done

The use of large doses of Cortisone will not overcome signs and symptoms dependent on irreversible changes

Results After Withdrawal of Cortisone —Signs and symptoms of rheumatoid arthritis usually recur when the administration of Cortisone or ACTH is stopped

The undesired effect of Cortisone in cases of infection is related to the possibility of failure of systemic defensive mechanisms for example in active tuberculosis syphilis, or septicemia, and of failure of the clinician to recognize the presence of intercurrent infections

Supplementary Measures —The rheumatoid patient treated with Cortisone also should receive other measures of assistance such as regular physical and occupational therapy avoidance of trauma to involved joints the use of salicylates as needed, the employment of a good general health program including adequate rest and a well-balanced diet, and the use of orthopedic devices and procedures as required

There is no doubt that compound E (Cortisone cortone) and ACTH are very helpful ACTH is given by hypo,' 4 times daily Cortone, the tablets of Cortisone when given orally have been demonstrated to be as effective as the hypodermic preparation The oral administration requires 25 per cent more especially at the beginning of treatment

When Cortisone is given one should prescribe a salt-free diet with supplementary potassium chloride

Compound F or hydrocortone presents a favorable outlook as a running mate for Compound E and ACTH

It is superior to Compound F for direct instillation into the knee in cases of rheumatoid and degenerative arthritis Some reports are very favorable The late reports on Compound F and Metacortin by oral administration are very encouraging

After listening to Walter Bauer's address before the American Academy of Orthopaedic Surgeons in January 1951 one is impressed with the thoughts that 1 One must still keep in mind all the basic knowledge that has accumulated over many years regarding the disease 2 The 'wonder drugs are not the complete answer to the arthritis problem One should consider rheumatoid and degenerative arthritis as two separate diseases They may appear in the same patient and in fact in the same joint The prognosis is often uncertain Many persons have to learn to live with it and make the best of it

Parathyroidectomy In 1926 Oppel demonstrated that a large number of patients with ankylosing polyarthritis had hypercalcemia which he attributed to malfunction of the parathyroid and advised unilateral parathyroidectomy

When there are signs of hypoparathyroidism immediately after the operation calcium and Vitamin D should be given

Ishmael has good results with testosterone Cecil Freyberg and others report favorable results with gold

There has been unanimity of opinion as to the effectiveness of Butazolidin in affording relief of pain in arthritis and in many allied musculoskeletal disorders Present evidence indicates it is capable of producing relief of pain in greater or lesser degree in a large percentage of patients with acute gouty arthritis rheumatoid arthritis and rheumatoid spondylitis

It has rapidly assumed an important place in the treatment of different types of rheumatic disease The medicine usually produces very good clinical improvement Most consistent is the relief of stiffness and joint pain, which allows significant increase in comfortable physical activity

Among the most remarkable effects of Butazolidin is the quick arrestment of acute gouty arthritis which had been resistant to colchicine In these patients there is prompt and significant reduction of plasma uric acid Stimulated by this consistent observation in gouty patients measurements of blood uric acid were made in rheumatoid arthritic patients and these too were found to be lower consistently

Troublesome side effects are chiefly indigestion anorrhexia nausea bloating ulcer symptoms edema and blood disturbance

Thyroid Implantations in Diseases of Joints Various diseases of the joints with primary chronic polyarthritis secondary chronic polyarthritis arthritis deformans spondylarthritis ankylopoietica and 4 spondylarthritis associated with sciatic pain were treated by Mandl and Gyri by implantations in the abdominal wall of 5 gm of thyroid tissue obtained from other patients during thyroidectomy

The effective thyroid implants neutralize the thyrotropic hormone of the pituitary and stimulate more profuse secretion of corticotropin Changes in adrenal cortex function were demonstrated by the rapidly decreased number of eosinophils in the blood

Physical Therapy—In arthritis of the spine the most valuable physical therapy agents are rest heat massage and local applications

The improvement of circulation is accomplished by rest heat special exercises inductotherm and diathermy locally and to the cervical and lumbar sympathetics

For patients with stiff back I would recommend exercises while in water at a temperature of 92° F In addition I advise exercises for the back while lying in bed especially for the abdominal gluteal and erector spinae muscles, postural exercises hot reclining baths and hot sitz baths contrast sprays warm and cool contrast applications The use of crutches is beneficial in preventing the telescoping of the torso and relieving the vertebrae of much superincumbent weight while walking

Colon Therapy includes irrigation implantation change of reaction diet and relief from stasis

oil and small doses of thyroid The diet should include fresh fruits, vegetables, whole wheat bread, milk, honey, meat and small amounts of carbohydrates, with very little white sugar, white flour or macaroni

The treatment of **rheumatoid spondylitis** involves removal of obvious infectious foci, daily use of physical therapy, hyperpyrexia, to induce lessening of muscular spasm, the use of postural and other spinal exercises, rib stretching and deep breathing exercises to prevent or correct impending fixation of the chest and spine, the use of a bed with a firm mattress on and semirigid springs to keep the spine straight at night, the use of one small pillow under the head, the use of a pillow between the scapulae or in the lumbar region for short periods during the day and night if kyphosis is developing The patient should keep a daily record of height and chest expansion In selected cases the use of a Taylor spine brace during the daytime and of a plaster shell or convex frame during the night gives considerable relief from pain and helps to prevent or correct forward bending of the spine

In the treatment of rhizomelic spondylosis Baker reported that combined orthopedic and roentgen therapies afford early relief from pain and muscle spasm It permits more rapid correction of deformities and more vigorous attempts at restoration of muscle balance

Jackets were left on for weeks and replaced by new ones as the posture improved, they were worn for periods ranging from several months to nine years Swaim reported that muscular spasm and pain were relieved rapidly, sleep was improved greatly, deformities were prevented or improved notably while expansion of the chest and weight increased

Chrysotherapy (injections of gold salts) has given varying results Freyberg and his colleagues recommended roentgen therapy for the relief from pain

In the **degenerative type** one must search for evidence of local trauma, static or mechanical disturbances and for occupational trauma One must educate the arthritic patient just as tuberculous and diabetic patients have been educated The removal of mental and physical overactivity, care or worry and the building up of the general resistance are imperative

A resume of the treatment of **hypertrophic arthritis** includes (1) rest, (2) reduction of weight if necessary, (3) physical therapy (4) diet (decrease the entire diet being especially careful about meat fish eggs and the carbohydrates), (5) prevention of deformities, (6) correction of static defects, such as postural disturbances of the body abdomen, back, legs and feet, (7) supports (8) reconstruction after the acute stage has passed of both the body and the joints

Foci of infection should be eradicated in the interest of good health and to benefit the arthritic joints indirectly

Deformities — Deformities of the spine are usually preventable but once started may become intractable When a patient is first seen steps should be taken at once to prevent the usual deformities from occurring Constant vigilance must be exercised to prevent the assumption of positions likely to lead to deformity Alternating rest and exercise of the joint are essential

Spinal deformity is either an exaggeration of the normal curves or a flat back

oil and small doses of the root. The diet should include fresh fruit, vegetables, whole wheat bread, milk, honey, meat, and small amounts of carbohydrates with very little white sugar or white flour consumption.

The treatment of rheumatoid spondylitis involves removal of infected foci; daily use of physical therapy to reduce lessening of muscular spasm; the use of postural and other exercises; rib stretching and deep breathing exercises to prevent or correct impending fixation of the chest and spine; the use of a bed with a firm mattress and semirigid spring to keep the spine straight at night; the use of one small pillow under the head; the use of a pillow between the scapulae or in the lumbar region for short periods during the day and night if kyphosis is developing. The patient should keep a daily record of height and chest expansion. In selected cases the use of a Taylor spine brace during the daytime and of a plaster shell or convex frame during the night gives considerable relief from pain and helps to prevent or correct forward bending of the spine.

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Spinal deformity is either an exaggeration of the normal curves or a flat back.

After a variable period during which pain disappears, a **plaster cast** or a **brace** is applied and crutches are prescribed

Physical therapy includes heat, massage, hydrotherapy, contrast sprays *hot paraffin applications mineral baths mud baths, passive exercises,* active exercises posture work, mechanotherapy manipulation, passive congestion, diathermy, inductotherm autocondensation and negative galvanism, colon therapy heliotherapy, climatotherapy and marinotherapy

Radiation Therapy —Roentgenotherapy and radium therapy are of definite value in relieving pain Oppenheimer claims that "During the initial and early stages of atrophic spondyloarthritis complete cure with disappearance of the lesions roentgenologically, can be obtained by roentgen therapy, employing small doses and intermediate penetration During the more advanced stages the lesion itself is irreparable, but roentgen therapy is useful in controlling pain and producing subjective improvement in vertebral mobility "

Favorable reports have come also from the clinics of Smyth Freyberg and Peck Baker S Gilbert Scott and several others The treatment of radiation sickness includes such prophylactic measures as graduated tolerable doses hypnotics dramamine picrotoxin and vitamin B_1 The curative treatment consists of *vitamin B_1 oxygen thorazine and discon-* tinuance of radiation Bonamine is effective

Foci of Infection —While the local treatment is being carried out thorough physical chemical bacteriological and serological investigations should be made to determine any underlying cause Examinations of teeth tonsils sinuses gall bladder appendix female pelvis and genitalia male pelvis genitalia and skin are made if disease is found it should be eradicated Roentgenograms especially of the teeth sinuses and abdominal viscera are valuable Complement-fixation tests for gonorrhea and syphilis are of aid Vaginal and urethral smears should be examined

Genito-urinary Tract —In treatment of the arthritic male the prostate and seminal vesicles are important In women treatment is directed to the urethra Bartholin glands Skene s ducts fallopian tubes the ovaries the kidney and *bladder Cervicitis or endocervicitis may follow parturition*

Respiratory Tract —Infections of the throat pharynx larynx bronchi and the lungs require appropriate treatment

Treatment of the Two Main Types of Vertebral Arthritis —The two types of arthritis are different processes a fact of paramount importance from the standpoint of treatment and prognosis

In the atrophic type one s efforts should be directed toward removing all foci of infection and building up the patient s general resistance In the hypertrophic type one should direct attention to resting the joint relieving strain, giving the joint support improving the local circulation and correcting abnormalities of *weight*

A résumé of the treatment of atrophic arthritis includes (1) rest (2) improvement of general mental and physical resistance (3) proper diet *including* sufficient vitamins (4) physical therapy (5) vaccines (6) removal of foci of infection (7) cod liver oil (8) medicine including tonics iron and calcium (9) regulation of weight and (10) endocrine gland products Most patients with atrophic arthritis should have heliotherapy cod liver

Operative Treatment	
Defocalization	Facetectomy
Manipulation	Rhizotomy
Fusion	Cordotomy
Decompression	Sympathectomy

Laminectomy.—In certain cases of arthritis of the spine where there is extreme localized pain which does not respond to routine measures, especially in the thoracic and lower cervical regions, laminectomy is advisable. Hemi-laminectomy may be performed where the referred pain is unilateral.

Spine fusion is indicated where fusion is inevitable and the painful period can be terminated.

Rhizotomy, the cutting of the nerve roots for intractable pain, is reserved for the most extreme cases.

Cordotomy consists in cutting part of the spinal cord, usually in the anterior horn region. It is a very delicate operation and requires the highest type of technic and the minutest anatomical knowledge and dexterity.

HYPERTROPHIC APTHRITIS OF THE VERTEBRÆ

Degenerative Arthritis (Hypertrophic Arthritis), Senescent Arthritis, Osteoarthritis. The spine is a favorite site for hypertrophic arthritis. Wilks designated this type of spondylitis as the "laborer's spine." The usual changes are osteocartilaginous proliferations about the margins of the vertebrae, fibrillation and irregularity of the articular cartilages.

Ankylosis of the spine does not occur primarily in this disease, although motion may be almost entirely prevented by the osseous overgrowths. Ankylosis of the sacro-iliac joints is a common associated finding. A combination of atrophic and hypertrophic arthritis may be seen in the same spine with ligamentous calcification and fusion of the spinal articulations.

In old age the joints, like other parts of the human machine, show the effects of wear and tear. It occurs in people past fifty years and in those who are overweight, who have had gastro-intestinal stasis, many of whom have done hard work and have postural and mechanical defects.

The etiology includes trauma and wear and tear. Old injuries, major and minor, and many forgotten episodes lay the ground work for future trouble, especially degenerative arthritis. Trauma always enters into the picture. It is often unknown to the patient or has been forgotten. Multiple minimal injuries ("Microtraumatic" or "Petitraumatic") are important. People do not realize the amount of trauma that operates during ordinary activities such as:

Gardening Athletics Swimming at the beach Handball Golf Suit case twists Bumps	Awkward position in performing simple acts In the home Injuries In the bath tub In the Military Services

In the neck torticollis is prevented by head suspension and the application of sand bags, rolled up blanket material to maintain proper posture cotton collar plaster casts or braces

Ossification of the intervertebral ligaments is less rapid and extensive when the spine is supported with a jacket early in the disease

MENOPAUSAL ARTHRITIS

According to Hall, investigation of the menopause and its symptoms in 1000 women showed that 23 7 per cent suffered from rheumatic pains at this time of life

Some observers believe that the menopause merely makes women more susceptible to the causes of arthritis, but that endocrine dysfunction is not the actual cause Others believe there is a clear-cut menopausal arthritis, due to a thyroid gland deficiency, responsible for various arthritic patterns Still others recognize only vasomotor arthralgias as occurring at the menopause, caused by ovarian gland deficiency and relieved by estrogen therapy

Hall reported a study of 71 women whose arthritis followed castration He treated most of them with large doses of estrogenic material over many weeks—some for months and years Fifty-three patients suffered from arthralgia rather than true arthritis Of 40, adequately treated, 80 per cent were materially relieved, while 70 per cent responded to the extent of almost complete relief of menopause and arthralgic symptoms Eighteen had true arthritis (atrophic hypertrophic or mixed) Fifty per cent of those with menopause symptoms and arthralgia were relieved of these symptoms and in some cases the arthritis was apparently improved by estrogen therapy

Ishmael s 48 patients with menopause arthralgia had satisfactory remissions following injections of stilbesterol used in conjunction with other supportive measures Forty-nine patients as controls responded satisfactorily to estrin injections along with the same supportive measures In 30 patients stilbesterol was successfully substituted for estrin with only 3 per cent having return of original symptoms Twenty-three patients receiving stilbesterol by mouth had clinical remission as compared to 10 patients who received estrin that responded by clinical remission He believes that stilbesterol should supplant the use of estrogenic hormone for two reasons (1) it is effective when given orally (2) the cost to the patient is greatly reduced

Enteric coated tablets are well borne by some persons who cannot tolerate the regular tablets

The Surgical Treatment of Arthritis of the Spine —The surgical treatment of arthritis of the spine consists of manipulative and operative procedures In manipulative surgery ethylene, nitrous oxide or ether should be used (The reader is referred to the section on Manipulative Surgery page 124)

Operations include those on the bones and those on the nerves

Operations on bone include decompression fusion and stabilization operations

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Gardening	Awkward position in performing simple acts
Athletics	In the home
Swimming at the beach	Injuries
Handball	In the bath tub
Golf	In the Military Services
Suit case twists	
Bumps	

Coventry warned his patients about overactivity. An excessive amount of work will aggravate and increase the degenerative changes in their back. Splinting is useful in cases of degenerative arthritis. A lumbosacral belt may give relief. A Taylor brace will splint both the lumbar and thoracic segments. Proper chairs should be used to splint the back when the patient is sitting. A firm bed is helpful. Heat should be prescribed. Massage tends to relax painful muscles and improve the local circulation. Medicinal therapy includes salicylates, and other drugs. Reduction of weight should be undertaken if there is any tendency toward obesity.

Vitamin B_1.—While investigating the possibility that the stimulating effect of vitamin B_1 on bone marrow might be of benefit in the treatment of osteoporosis, Hallaham observed that a number of patients with osteoarthritis who were among the controls, experienced decided relief of their symptoms. One hundred micrograms of crystalline vitamin B_1 were given intramuscularly once a week. During the three-week period, 12 patients were completely relieved and all but two of the remainder had obtained complete relief in some joints and had partial relief in others. X-ray examination revealed advanced osteoporosis of all vertebrae with compression fractures of the bodies of TH-11 and TH-12.

RHEUMATOID OR ANKYLOSING ARTHRITIS OF VERTEBRÆ

Rheumatoid Spondylitis

Rheumatoid spondylitis (a term proposed by the American Rheumatism Association in preference to "Marie-Strumpell's arthritis") is an inflammatory nonspecific disease affecting principally the sacroiliac and facet joints of the spinal column. The inflammatory process also may affect the periarticular fibrous and other mesenchymal tissues. The etiology is unknown. The onset of rheumatoid spondylitis could be related to trauma in only 7 per cent of more than 1,000 cases studied at the Mayo Clinic by Polley.

Most European rheumatologists are of the opinion that rheumatoid spondylitis is unrelated to rheumatoid arthritis of peripheral joints. The consensus among most American rheumatologists is that these diseases are closely related. Twenty five to 50 per cent of patients with rheumatoid spondylitis have associated arthritis of peripheral joints. The prevailing opinion about the cause of rheumatoid spondylitis is summarized in the statement that "presumably the cause of rheumatoid spondylitis is the same as that of peripheral rheumatoid arthritis" (Hench *et al.*).

Ankylosing spondylitis is a disease of the spine, the sacro-iliacs, small intervertebral and costovertebral joints, with later calcification of the paravertebral ligaments. The disease has its insidious onset usually between sixteen and forty years. About 90 per cent of cases occur in men. Early symptoms are pain and stiffness referred to the low back and buttocks. Fatigue, weight loss and anorexia are constitutional symptoms. The cause of ankylosing spondylitis is unknown. The relationship between ankylosing spondylitis and rheumatoid arthritis is also uncertain.

There is an increase of the calcium content of the pelvic bones supporting the spine. Buck considers the possibility of a toxin from the prostate

influencing the process of phosphatase activity on bone resorption and deposition. Stecher and Hauser described a pair of brothers with ankylosing spondylitis. Heredity evidently plays an important role in the etiology.

Rheumatoid Arthritis of Traumatic Origin. – Jonsson quotes Kauffmann's five criteria for acceptance of this diagnosis: 1. The joint must have been normal before the trauma in question. 2. The patient must not have suffered from polyarthritis earlier. 3. The injury to the joint must be considerable. 4. The signs of polyarthritis must have begun in the injured joint. 5. The interval between the trauma and the onset of polyarthritis must not be longer than one to ten days. Berglund and Jonsson found only one such case among 2,236 cases of polyarthritis. The attitude of insurance authorities and institutions varies. It may well be that rheumatoid arthritis has been unnoticed before a joint is injured.

Ankylosing spondylitis usually starts as a destructive arthritis of the sacro-iliac joints with juxta-articular osteitis. It affects young men in a ratio of about 14 to 1 woman. As it progresses it produces painful spasms of the spinal muscles, calcification of the vertebral ligaments (eventually producing the bamboo pole spine in roentgenograms) and arthritis of the apophyseal joints. Spinal kyphosis and fixation of the chest wall may result in spite of every available therapeutic measure.

One of the leading radiologists of England, S. Gilbert Scott, describes a type of patient who if taken in time can be saved but if neglected either through misdiagnosis, ignorance, or delay will become what he calls a spondylitic wreck.

If prevention is not possible the next best thing is early diagnosis and arrest of the pathological process. The clinical diagnosis of spondylitis can be made five years before the onset of spinal symptoms which can be arrested by the use of wide field roentgen therapy during the prespondylitic stage.

Spondylitis deformans includes any type of spondylitis that leads eventually to deformity. There is the spondylitis that attacks the young adult—known as ankylosing spondylitis, or preferably adolescent spondylitis—and the spinal arthritis of the elderly or aged patient—known as spondylitis osteoarthritica or old man's spondylitis.

Scott suggests the term adolescent spondylitis for ankylosing spondylitis that attacks the young adult. The onset is insidious, extending over a period of five to seven years before the appearance of spinal symptoms. It attacks the young healthy athlete, usually the male. Infective changes are always present in the sacro-iliac joints. During the active stages of this joint infection no pain is felt either over the sacro-iliac joints or in the back. Bony ankylosis of the sacro-iliac joints is nearly always complete by the time the clinical signs of spondylitis appear. The condition always begins in early adult life in spite of the fact that symptoms may sometimes be delayed until late middle age. Attacks of rheumatic pains referred not to the back or sacro-iliac joints but to various parts of the body, occurring in a young adult over a period of years, should suggest a radiological study of the sacro-iliac joints. Adolescent kyphosis is not a pathological entity but an excessive kyphosis associated with the final stages of adolescent spondylitis.

The onset of infection in the sacro-iliac joints does not coincide with the onset of spinal symptoms of spondylitis The painful and stiff spine, so characteristic of spondylitis represents the last and not the first chapter of the disease Over 90 per cent of the patients Scott examined had been good swimmers The only clinical sign present may be pain in the hip or ankle, or in any part except the back or the sacral region Changes of some sort can actually be detected by means of a radiographic examination several years before there is any clinical suspicion that the patient may eventually develop spondylitic symptoms Scott finds the most reliable information is obtained from roentgenograms taken in the routine standard projections

Scott describes the advances in obtaining a complete radiographic record of sacro iliitis He is responsible for the treatment of sacro iliitis which Americans call sacro-iliac disease or sacro-iliac arthritis He describes prespondylitic symptoms and recurrent attacks of rheumatism in the young adult as wandering pains and growing pains These patients sometimes have abdominal symptoms resembling girdle pains which have led to the erroneous diagnosis of gastric ulcer or gall bladder disease One unfortunate characteristic of these prespondylitic cases is that they have a definite tendency to be intermittent This temporary remission gives both the doctor and the patient a false sense of security

The remarkable results Scott has obtained with wide field roentgenray therapy in one series of 300 cases of spondylitis in all stages extending over a period of eight years justifies his conclusions that arrest of this disease is possible in a large majority of if not in all cases provided they are treated during the prespondylitic period

The person with a painful back who feels worse after rest who has tenderness over one or both sacro-iliac joints and who has a high sedimentation rate is most likely suffering from rheumatoid spondylitis X-ray may reveal loss of definition of joint margins and irregularity plus sclerosis of the sub articular bone surrounding both sacro iliac joints The usual complaints are pain and stiffness referred to the lower back and buttocks pain increased by coughing, breathing or straining sciatic pain fatigue weight loss anorexia and fever

The Manual distributed by the Arthritis and Rheumatism Foundation lists the following *Criteria for the Diagnosis of Ankylosing Spondylitis*

1 The patient is usually a young man in the second or third decade of life

2 Symptoms of chronic systemic disease especially loss of weight and strength

In early cases the only symptom may be low back pain Minor changes in the sacro iliac joint then assume decisive importance

3 Low-grade fever and leukocytosis is present in some cases with frequent secondary anemia the sedimentation rate is usually elevated

4 The patient presents a typical picture a thin young man with stooped shoulders and head held rigid Examination of the lumbar spine reveals characteristic flattening in the lumbar region marked spasm of the erector spinæ muscles and limitation of chest expansion

5 X-ray shows generalized osteoporosis fusion of the intervertebral articulations and calcification of the longitudinal ligaments The sacro iliac joints are involved in 90 per cent of cases and often afford the earliest roentgenologic evidence of the disease

6. Roentgen therapy is of considerable value.

Symptoms.—Rheumatoid spondylitis is often unrecognized in its early stage. The *outstanding clinical features of the disease* are listed by Comroe as follows:

1. Pain.
2. Stiffness.
3. Rigidity of the thoracic cage and back.
4. Tenderness locally over the sacroiliac joints and spinous processes.
5. Systemic manifestations.
6. Marked predominance in the male sex, especially during the second, third or fourth decades.

Symptoms of Rheumatoid Spondylitis (Comroe)
Symptoms usually appear between twenty and forty years of age
Gradual onset in about 90 per cent of the cases
Occasional acute onset with fever, leukocytosis, rapid sedimentation rate, severe root pains
Marked predominance in males (10:1)
Early stage: shifting rheumatic pains in the limbs or trunk for days or weeks (intermittently for months or years)
Later: *low back or sacro-iliac pain*; marked discomfort at night made worse by lying down and *relieved by getting up and moving about*, or by massage
Stiffness, especially in the early morning, lessening after mild exercise
Later may have pain, stiffness and rigidity along entire spine
Root pains on one or both sides (with numbness and loss of power in the arms or legs); girdle pains and pains radiating down the extremities
Spasm of paravertebral muscles, followed by muscular atrophy in the back
Pain on motion of the spine and on deep breathing, coughing or sneezing
Sciatica in about 40 per cent of cases
Pain on pressure or tapping over and lateral to the spinous processes
Areas of hyperalgesia
Stiffness in the back with increasing rigidity (until a poker spine occurs)
Kyphosis and a position of forward flexion of the spine as the disease progresses
Inability to stand erect; inability to look up or to turn about without moving the entire body
Flattening of the chest and decreased or absent expansion of the chest during respiration; reduction of vital capacity
Slow, shuffling, bent-over gait
Pain decreases but stiffness increases in later stages
Characteristic roentgen findings

The *onset* is usually *insidious* and the progress of the disease extremely slow. Acute cases occur occasionally.

Physical examination shows, in addition to deformities, extensive limitation of movement of the affected parts of the spine and decreased thoracic expansion. Roentgenograms of the entire spine are helpful in supporting the diagnosis. If the disease is active, the erythrocyte sedimentation rate is usually elevated.

The onset of infection in the sacro-iliac joints does not coincide with the onset of spinal symptoms of spondylitis. The painful and stiff spine, so characteristic of spondylitis represents the last and not the first chapter of the disease. Over 90 per cent of the patients Scott examined had been good swimmers. The only clinical sign present may be pain in the hip or ankle or in any part except the back or the sacral region. Changes of some sort can actually be detected by means of a radiographic examination several years before there is any clinical suspicion that the patient may eventually develop spondylitic symptoms. Scott finds the most reliable information is obtained from roentgenograms taken in the routine standard projections.

Scott describes the advances in obtaining a complete radiographic record of sacro-iliitis. He is responsible for the treatment of sacro-iliitis which Americans call sacro-iliac disease or sacro-iliac arthritis. He describes prespondylitic symptoms and recurrent attacks of rheumatism in the young adult as wandering pains and growing pains. These patients sometimes have abdominal symptoms resembling girdle pains which have led to the erroneous diagnosis of gastric ulcer or gall bladder disease. One unfortunate characteristic of these prespondylitic cases is that they have a definite tendency to be intermittent. This temporary remission gives both the doctor and the patient a false sense of security.

The remarkable results Scott has obtained with wide field roentgenray therapy in one series of 300 cases of spondylitis in all stages extending over a period of eight years, justifies his conclusions that arrest of this disease is possible in a large majority of, if not in all cases, provided they are treated during the prespondylitic period.

The person with a painful back who feels worse after rest, who has tenderness over one or both sacro-iliac joints and who has a high sedimentation rate is most likely suffering from rheumatoid spondylitis. X-ray may reveal loss of definition of joint margins and irregularity plus sclerosis of the subarticular bone surrounding both sacro-iliac joints. The usual complaints are pain and stiffness referred to the lower back and buttocks, pain increased by coughing, breathing or straining, sciatic pain, fatigue, weight loss, anorexia and fever.

The Manual distributed by the Arthritis and Rheumatism Foundation lists the following *Criteria for the Diagnosis of Ankylosing Spondylitis*:

1. The patient is usually a young man in the second or third decade of life.
2. Symptoms of chronic systemic disease, especially loss of weight and strength.

In early cases the only symptom may be low back pain. Minor changes in the sacro-iliac joint then assume decisive importance.

3. Low-grade fever and leukocytosis is present in some cases with frequent secondary anemia; the sedimentation rate is usually elevated.
4. The patient presents a typical picture: a thin young man with stooped shoulders and head held rigid. Examination of the lumbar spine reveals characteristic flattening in the lumbar region, marked spasm of the erector spinæ muscles, and limitation of chest expansion.
5. X-ray shows generalized osteoporosis, fusion of the intervertebral articulations and calcification of the longitudinal ligaments. The sacro-iliac joints are involved in 90 per cent of cases and often afford the earliest roentgenologic evidence of the disease.

Ferguson's study offers considerable evidence in support of the clinical conception that rheumatoid arthritis, Still's disease and rheumatoid spondylitis are intimately related.

Forestier noted that the contour of the subchondral bone of the sacro-iliac joint becomes indistinct and hazy, the joint loses its clear cut margins and becomes indistinct. This marginal decalcification causes the joint to appear widened. Somewhat later sclerosis begins to appear at the margins of the joints. The process gradually progresses until there is loss of the joint space and fibers of bone are seen growing across this space. These osseous fibers are the first evidence that ankylosis is developing and this process progresses until ultimately there is smooth bony ankylosis of the joints. If the diagnosis of rheumatoid spondylitis is to be made early in the course of the disease the roentgenologist must search carefully for those early manifestations of the disease which consist of decalcification at the margins of the joint with resultant indistinct outlines of the joint. A moderate degree of marginal sclerosis occurs fairly early many times but dense sclerosis of the bone and ankylosis are late manifestations of the disease.

Roentgenologic evidence of vertebral involvement almost always appears much later than that of sacro-iliac involvement. In routine lateral roentgenologic views Pugh describes the first apparent change in the vertebra indicative of rheumatoid spondylitis as a peculiar "squaring-off" of the vertebral bodies. This change usually is evident in the thoracolumbar region first and it is due to fine calcification of the anterior longitudinal ligament which causes a filling in of normally concave anterior vertebral surfaces and squaring off of the anterior vertebral angles. Later on in the disease, calcification of the vertebral ligaments is more obvious and appears in the roentgenogram as fine lines of calcification which cross from the margin of one vertebral body to the next.

Hench found the x-ray examination of the sacro-iliac joints the most useful aid in the diagnosis. Scott emphasized the importance of a routine roentgen examination of the sacro-iliac joints. He finds that typical changes in the sacro-iliac joints are pathognomonic of the disease, that they are present in every case and that they appear earlier than the spinal changes. His published material comprises 500 cases.

Knutsson described the arthritic process in the sacro-iliac joints in the following stages: 1. The initial stage. The earliest change is manifested by an opacity of the contours of the joint surfaces together with an indication of sclerosis on the iliac side of the joint. 2. The destructive stage. Erosion and sclerosis involve the iliac side of the joint. 3. The ankylosing stage.

The diagnosis is made from the clinical, radiological and serological findings. The disease usually begins in young male adults. There is deep pain first localized across the sacro-iliac area, later spreading upward toward the lumbar and thoracic spine. In progressive cases the cervical spine and sometimes the hips are involved. In a typical established case the main features found on examination are gross rigidity of the spine and markedly diminished chest expansion. The two findings most helpful in confirming the diagnosis are: (1) the demonstration of roentgenographic changes in the sacro-iliac joints, and (2) the presence of an elevated sedimentation rate.

Radiologically the first changes are seen in the sacro-iliac joints. There is loss of the sharp outline of the joint margins. Later, bony ankylosis occurs. As the disease progresses changes of a similar nature are seen in the lumbar, thoracic and often in the cervical spine. There is destruction and obliteration of the facet joints and bridging of the vertebral bodies by ossification of the longitudinal ligaments. In cases with hip involvement there is progressive narrowing and, later, bony ankylosis of one or both joints. The stiffness of the spine precedes the radiological changes.

The first x-ray changes are usually in the sacroiliac joints. Key describes an irregular destructive process. The anterior and posterior edges of the joint become blurred and serrated. Next the cartilage space is destroyed and slight sclerosis becomes evident in the periarticular bone of the sacrum and ilium. The destruction and sclerosis proceed until the joint is destroyed and ankylosis takes place; this is usually the situation on diagnosis.

Roentgen Findings in Rheumatoid Arthritis of the Spine (Comroe)

1. *Haziness* of the *sacro-iliac joints*.
2. *Narrowing* of the *sacro-iliac joint space*.
3. *Decalcification* of the *vertebræ*.
4. Increased bone production along the sacro-iliac joint margins, eventually leading to *fusion*.
5. *Similar process involving the apophyseal joints* of a portion of, or of the entire spine, usually beginning in the lumbar region and progressing upward—but occasionally being noted first in the cervical area.
6. In an advanced stage, *calcification* of the *anterior and lateral spinal ligaments*.
7. *Pain, stiffness and other symptoms may precede the roentgen findings by months or years.*
8. *Peripheral joint involvement* of the *hips* and *shoulder joints* are involved not infrequently (in what appears to be a typical rheumatoid arthritic process). The sternoclavicular joint and temporomandibular joints may be involved.

Forestier describes three stages: (1) pseudowidening of the joint with decalcification and fuzziness of subchondral bone; (2) mottling of the cancellous bone in a wide area on either side of the joint; and (3) loss of joint space and syndesmosis.

The roentgenological observations in the cases of rheumatoid spondylitis observed by Taylor, Ferguson, Kasabach and Dawson were similar to those noted in cases of rheumatoid arthritis except for the anatomical distribution. The atrophic destruction of bone and the changes in the soft tissues were not well defined because of the location of the affected joints in the spine. Systemic decalcification was present in 100 per cent of their cases.

Ankylosis of the intervertebral facets which was present in 100 per cent of cases was almost invariably accompanied by obliteration of the sacro-iliac joints. Calcification of the spinal ligaments was observed in 100 per cent of the cases. The bamboo rod appearance of the spine is characteristic

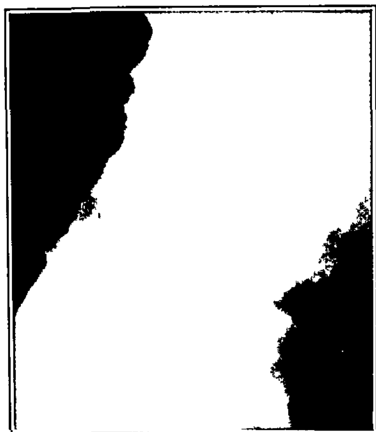


Fig. 158.—Ankylosing vertebral arthritis. Calcification of anterior spinal ligaments

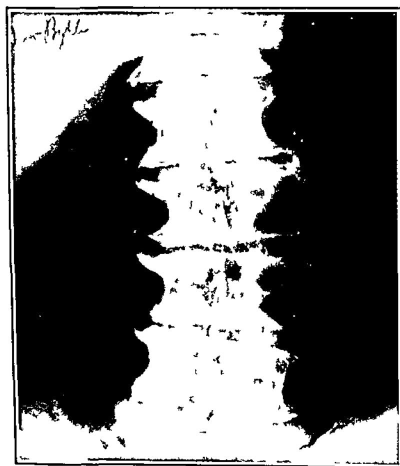


Fig. 159.—Vertebral arthritis—platyspondylis

Turney regards roentgenologically demonstrable changes in the sacro-iliac joints of primary importance in the diagnosis. Most patients with the disease are young men and in at least 90 per cent the onset is between the ages of twenty and forty. Early symptoms may be so mild that medical advice is not sought or the diagnosis not made. The first symptom is usually an intermittent aching in the lumbar region, hips, and thighs. If no treatment is given, the pains persist and movement of the spine becomes increasingly restricted, rigidity starting in the lumbar region and spreading upwards. Iritis occurs in about 20 per cent of cases.

The chief features in spondylitis are calcification of ligaments and bony ankylosis, although around the affected joints there is some rarefaction of the bones; there is no general osteoporosis. The reverse is true of rheumatoid arthritis; that is, there is osteoporosis, but calcification is absent. The effects of x-ray and gold therapy are diametrically opposed; x-ray therapy is helpful in spondylitis and gold therapy in rheumatoid arthritis. The earlier deep x-ray therapy is started the greater the likelihood that the disease will be arrested.

Boland and Present listed the following conditions under which rheumatoid spondylitis should be suspected:

1. Suspect rheumatoid spondylitis when a young man complains of chronic recurrent or persistent low back aching and stiffness with or without "catching" pains, especially if the sedimentation rate is elevated.

2. Suspect rheumatoid spondylitis in the young man who complains of such vague symptoms as a "tired feeling" in the lower part of the back on standing and walking, persistent low back soreness, restriction of back motion, or indefinite sharp pains in the buttocks, hips or lower part of the back, especially if accompanied by an elevated sedimentation rate or general constitutional symptoms.

3. Suspect rheumatoid spondylitis in all cases of sciatica in young men, particularly if recurrent or alternating from side to side or associated with aching and stiffness of the lower back.

4. *Suspect rheumatoid spondylitis in patients with thoracic girdle pains*, especially if accompanied by symptoms in the lower part of the back.

5. Suspect rheumatoid spondylitis when persistent back symptoms develop in a patient with peripheral rheumatoid arthritis.

6. In the absence of roentgenographic evidence of sacro-iliac involvement an unequivocal diagnosis of rheumatoid spondylitis should not be made unless characteristic changes are present in the apophyseal joints.

7. Characteristic roentgen-ray changes in the sacro-iliac or apophyseal joints may not develop for months after the onset of symptoms. Do not eliminate the possibility of rheumatoid spondylitis on negative roentgen rays alone unless persistent symptoms have existed for at least 3 years.

8. Definite bilateral destructive and/or sclerotic changes in the sacro-iliac joints, noted roentgenographically, almost invariably indicate rheumatoid spondylitis.

9. Be cautious in making a diagnosis of rheumatoid spondylitis with unilateral sacro-iliac involvement unless other characteristics of the disease are present or unless peripheral rheumatoid arthritis coexists. Persistent unilateral sacroiliitis may be due to tuberculosis.

Stone, Spies and Niedermeier gave their patients a series of injections of pituitary adrenocorticotrophic hormone then injections of cortisone, the rationale being that one overstimulates the adrenal cortices and the other tends '*to put them to sleep*'

Non-mercurial diuretics (Diamox) help those persons who have water retention. Thorazine helps others.

Compound F.—Compound F or Hydrocortone can be injected directly into joints. It is helpful in treating some patients with arthritis not relieved by cortisone. A new butyl alcohol preparation has been highly recommended.

Osteotomy of the Spine for Correction of Flexion Deformity in Rheumatoid Arthritis.—Smith-Petersen confines the operative procedure to the laminae and articular facets and does not involve the vertebral bodies.

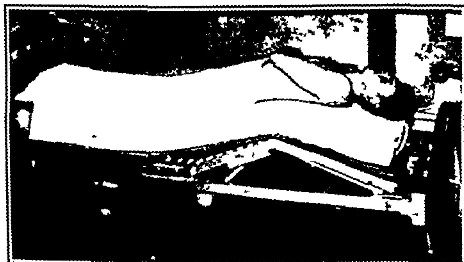


FIG 160.—Baker's modification of Gatch bed for arthritis. Useful in fractures of vertebrae. Sponge rubber or latex mattress. Hinged fracture-board. Patient's head toward foot of bed. (Baker, courtesy Jour. Bone and Joint Surg.)

The lumbar region is more favorable than the thoracic since the latter commonly presents ankylosed costovertebral joints rendering correction difficult, if not impossible.

In the article by Smith-Petersen *et al.* (1945) who had performed the operation in five *cases of ankylosing arthritis they laid down certain general* principles (1) that the osteotomy must be done in the lumbar spine to avoid the splintage of the ribs and their articulations, (2) that the osteotomy must include the articular facets, as ossification at these facets is the most important single factor in preventing correction of deformity, and (3) that the operation should not be delayed too long. The optimum time is immediately after the acute phase begins to subside.

La Chapelle (1946) described a simpler single osteotomy, but he combined this with a description of forcible rupture of the anterior spinal ligament. Herbert (1948) described a two stage operation. The second stage consisted in a lateral approach to the anterior aspect of the vertebral bodies, division of the anterior common ligament and if necessary, the placing of a wedge graft from the tibia between the bodies.

10 Calcification of the paravertebral ligaments in itself is not sufficient evidence for the diagnosis of rheumatoid spondylitis, changes in the apophyseal and/or sacro-iliac joints must also be present

11 The sedimentation rate may be normal in 15 to 20 per cent of cases with active disease and constitutional symptoms are usually milder than in rheumatoid arthritis involving peripheral joints

Treatment consists of a well rounded program aimed at improving the patient's general health, relief of symptoms and prevention of deformities

Management should include use of a firm bed consisting of substantial springs on which there is a semi rigid airfoam mattress Moderation of physical activity, analgesia with salicylates and exercise to improve muscle function and posture are prescribed If there is true muscle spasm, antispasmodic drugs may contribute some relief If ankylosis and calcification of spinal ligaments have not developed to a high degree, Freyberg finds that *roentgen therapy over the spine and paraspinous tissue* might afford relief ACTH and cortisone are effective in the control of this disease

Treatment of Rheumatoid Spondylitis (Comroe)

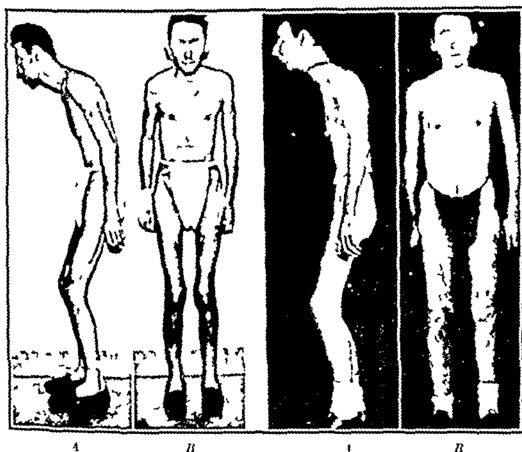
Absolute *rest in bed* in severe cases *for periods of a month or more*
Gradually *remove pillows from under the head*
After several days, attempt to correct or prevent forward bowing of the chest and fixation of ribs in downward inclination
The patient lies on his back on a *firm mattress* with a small firm pillow *placed under the most prominent part of the spinal deformity for* thirty minutes several times a day
Gradually use a larger pillow or small sand bag
If there is difficulty in producing motion of the ribs use a posterior molded shell with ridges placed to exert pressure upon the angles of ribs posteriorly
Hot fomentations to the entire spine for twenty minutes twice a day
Frequently change the *plaster shells* or jackets as improvement occurs
Breathing exercises to increase thoracic capacity
When the active disease becomes quiescent use exercises with the patient sitting on the edge of the bed and later in a chair *avoid muscle spasm*
If the spine is not straightened within several weeks apply a light plaster jacket and renew this at regular intervals
When maximum correction has been obtained apply a waxed leather or celluloid jacket this should be worn for several years

Treatment Resolves Itself Into

1 Relief of symptoms
2 Arrest of the disease
3 Prevention of deformity
4 Corrective surgery
5 Rehabilitation

between the first and second lumbar vertebrae. The bone was removed with a fine osteotome and nibbling by forceps. The gap began to close spontaneously as the osteotomy was almost completed. Some difficulty was experienced in getting the spinal bone from the left sided wedge because the instruments were gripped by the closing laminar remnants. The wound was closed and the patient placed on a divided bed.

There was probably little further correction once the patient left the table. After seven days the bed was made solid. After three months an Albee graft was placed over the osteotomy site. The patient was allowed up six months after the first operation. Figure 162 shows the degree of correc-



A B A B

Fig. 162.—Smith-Petersen osteotomy of the spine for correction of flexion deformity in rheumatoid arthritis. A, before treatment; B, after treatment.

tion which can be obtained by lumbar osteotomy. An alternate procedure is osteotomy of the femurs to tip the patient's head and torso backward.

Herbert reports on 20 vertebral osteotomies performed by a technic which aimed at cutting first the posterior vertebral arch and then the disk opposite this arch. The technic varied somewhat according to the contour of the spinal column but in most cases the operation was carried out at the junction of the thoracic and the lumbar sections. In one case osteotomy was performed at the junction of the cervical and thoracic sections and in another case on the upper thoracic division of the spine. The operation is especially indicated in cases of severe kyphosis caused by ankylosing spondylarthritis. Results were always good, the invariable end result being correction of the deformity, so that the spine regained its normal balance.

A late complication was stiffening of the hips

Stuart and Rose performed an osteotomy between the first and second lumbar vertebræ, and removed the bone with a fine osteotome and nibbling forceps

A course of deep x-ray therapy was given to the patient's hips, a plaster spica was applied including one hip

They employed the technic of La Chapelle but the anterior ligament was not forcibly ruptured

Lumbar osteotomy was performed with the patient on his right side to avoid pressure of the prone position and to remove more bone on the left side for correction of the lateral deviation Osteotomy was accomplished

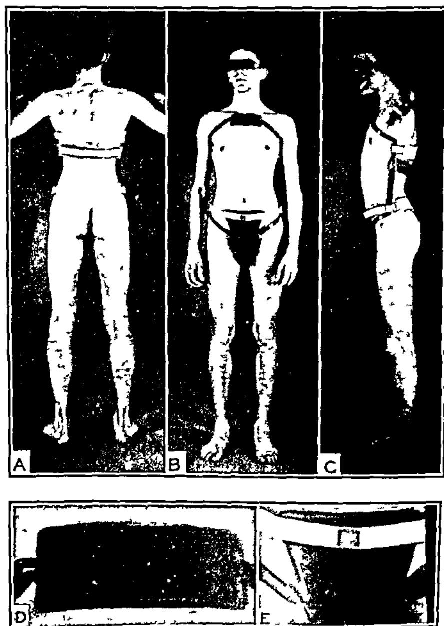


Fig 161 —Spine brace designed by Baker Note abdominal pubic and manubrial pad and 3 point pressure (Baker courtesy Jour Bone and Joint Surg)

between the first and second lumbar vertebrae. The bone was removed with a fine osteotome and nibbling by forceps. The gap began to close spontaneously as the osteotomy was almost completed. Some difficulty was experienced in getting the spinal bone from the left sided wedge because the instruments were gripped by the closing lumbar remnants. The wound was closed and the patient placed on a divided bed.

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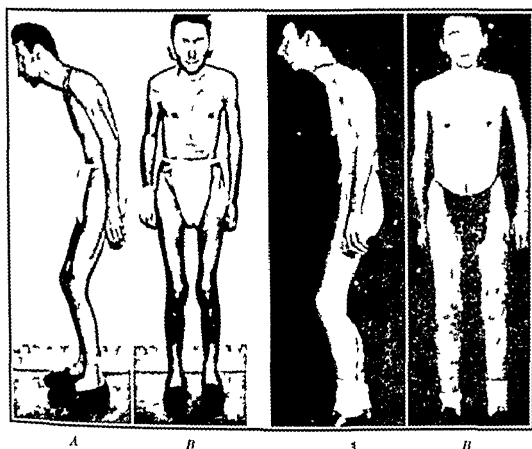


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GOUTY AFFECTIONS OF THE BACK

My reason for including a short section on gouty affections of the back is based on clinical experience rather than on technical accuracy

Gout is due to a disturbance of purine metabolism characterized by pain and hyperuricacidemia It is possible for patients to have a normal uric acid concentration in the blood during an early acute attack

I can not accept the statement that "there is more gout in the back than in the big toe" While the statement is not true it serves a purpose in calling attention to the fact that the "gouty state" can be reflected in the back, *especially in overweight middle-aged men*

Hench's "Goutograms"—Relatively trivial trauma may provoke an attack, the severity of which is out of proportion to the trauma

An attack may follow dietary indiscretions

Acute arthritis occurring within the first six days after an operation may be gout

The trauma, exposure and the dietary excesses of fishing hunting and vacation trips are common incitants

About 98 per cent of patients who have gout are men

Gouty arthritis is the most common form of acute arthritis to affect men more than forty years old

While an attack may come on at any time during the day or night it is especially prone to occur between 2 A M and 7 A M

Maximal pain is usually reached within thirty-six hours of the onset of any attack

From one to two or more joints are involved Pain in the big toe joint is present in approximately 60 per cent of attacks

Attacks usually vary from seven to twenty-one days

The tendency to full restitution of joint function is notable

Olecranon bursitis is common in gout

Attacks of renal colic or nephritis not uncommonly develop in cases of gout

Prodromes of a gouty attack may be gastro intestinal disturbances irritability dizziness and urinary symptoms

The response to therapy is practically diagnostic

An acute attack may be aborted by taking a brisk cathartic and a few doses of colchicine at two or three hour intervals Glucose or saline solution given intravenously is usually helpful

During an attack attention must be directed to rest, heat or cold a cathartic, colchicine, cinchophen diet and possibly narcotics Complete rest in bed until pain and tenderness disappear is advisable

Magnesium sulfate from ½ to 1 ounce magnesium citrate from 6 to 12 ounces, or sodium phosphate from 4 to 8 gms may be given empirically

Hot water compresses are preferable to dry heat In some cases cold compresses give more relief Such lotions as aconite belladonna or chloro-

form are prescribed by some physicians. Sweat baths are usually beneficial.

Colchicine tablets each $\frac{1}{120}$ or $\frac{1}{100}$ grain, should be given, (2 tablets initially and 1 tablet every two or three hours, even during the night when the attack is severe) until pain is relieved, or nausea or diarrhea appear.

Until pain is controlled by colchicine and compresses a dose or two of codeine (from $\frac{1}{2}$ to 1 grain) or morphine sulfate (from $\frac{1}{8}$ to $\frac{1}{4}$ grain) may be required.

Cinchophen should be given during attacks thus: $7\frac{1}{2}$ grains three or four times daily with proper precautions. (Alkali, carbohydrates, extra fluid.)

Some physicians prefer one of the following substitutes during the attack: neocinchophen from 5 to $7\frac{1}{2}$ grains three times a day, sodium salicylate 20 grains four times a day or acetylsalicylic acid 20 grains three or four times a day.

The diet approved for acute gouty arthritis is free of purines and low in fats, rich in carbohydrates (which increase urate excretion) and rich in purine-free proteins (milk, eggs, cheese).

Complete abstinence from alcohol is advisable.

During an acute attack a patient with gout should be on a purine-free diet. After the attack is over he should continue on a purine-low diet four or five days a week and a purine-free diet two or three days a week.

Prophylaxis should be based on a proper diet, physical education and treatment at mineral springs. The latest therapeutic contributions are Butazolidin, and a combination of benemid and para amino salicylic acid.

The diet should be entirely or nearly purine-free. Foods rich in nucleins, liver, thymus, kidney, brain, pancreas, anchovies, sardines, herring, caviar, fish roe, meat extracts and bouillons should be prohibited. The ideal diet is composed chiefly of milk, cream, cheese, eggs, fruits and fresh vegetables.

All malt liquors, wines and other alcoholic beverages are contraindicated. Fluids should be taken freely. Foldes advised an anti-retentional diet to prevent the accumulation of water in the tissues. One should beware of concentrating the blood and urine.

The internal administration of atophan or colchicum often affords striking relief of the symptoms.

Hench, Rutledge and Bedard suggested a combination of salicylates and amino-acetic acid as an effective substitute for cinchophen.

The purpose of giving alkali during cinchophen administration is to prevent urates which are being excreted in excess from precipitating as stones or gravel in an acid urine.

Massive doses of thiamin chloride used in conjunction with the generally accepted routine management for gout, appear to reduce the period of disability.

Adrenalin is helpful in a gout crisis.

ACTH can cut short an attack of gout in four hours.

The recent advances in the treatment are the use of Benemid and Butazolidin.

Benemid has been found by Talbott and others to be very helpful. It appears to complement rather than supplant colchicine.

Talbott reports favorable results from the use of Benemid both during acute attacks and during the intercritical periods PAS may be combined with Benemid

Butazolidin has been heralded by many rheumatologists as the great advance in the treatment of gout

The latter is an excellent drug but must be carefully controlled I never prescribe more than one week s supply A blood count is required before the prescription will be renewed

FIBROSITIS

The term fibrositis is applied to the syndrome characterized by pain, stiffness, aching, soreness and tenderness in any area that is known to contain fibrous tissue. The condition is also characterized by "post-inertial dyskinesia."*

According to Dawson the term "primary fibrositis" is applied to a group of diseases including "psychosomatic rheumatism," bursitis, postural strain, occupational and traumatic conditions.

Fibrositis means irritation of fibrous tissues. Fibrosis is a better term. The resiliency of tissues is diminished. Circulatory disturbances are common. The symptoms and signs are like arthritis without x-ray findings. Any fibrous connective tissue may be involved such as:

Capsule	Muscles
Synovia	Tendons
Ligaments	Skin

The lesions may be para-articular, peri-articular or juxta-articular.

The causes are unknown, or at least poorly understood. A diminishing number of experts doubt the existence of fibrositis as an entity.

Fibrositis is important in relation to the back, hips, neck and pelvis. It is analogous to a local aging process. The tissues do not stretch quickly or normally. When they do stretch or are forcibly stretched there is a slow return to normal—or near normal.

The psychologic reaction is often worse than the reaction to arthritis.

In fibrositis one is confronted with a classical example of a psychosomatic syndrome.

The chief physical findings are trigger points or tender areas. There may be fibrous nodules. An important characteristic is the absence of x-ray findings. The diagnosis is made by exclusion. Even if the x-rays visualize some arthritis it may be fibrositis that is causing the complaints. Likewise normal laboratory tests are the rule.

It may be summarized as:

1. Rheumatism without x-ray changes
2. Arthritis that is one anatomical step removed from the joints
3. Non-articular rheumatism
4. Psychogenic rheumatism
5. Muscular rheumatism
6. Psychosomatic rheumatism

* A term suggested by Lewin to mean "pain and stiffness upon resuming activity after a period of rest."

Talbott reports favorable results from the use of Benemid both during acute attacks and during the intercritical periods. PAS may be combined with Benemid.

Butazolidin has been heralded by many rheumatologists as the great advance in the treatment of gout.

The latter is an excellent drug but must be carefully controlled. I never prescribe more than one week's supply. A blood count is required before the prescription will be renewed.

Treatment is Symptomatic — Fibrositis is usually relieved by controlled activity, limbering up exercise, stretching exercise, heat, massage, ethyl chloride sprays, procaine injections, diathermy or manipulative maneuvers. In many cases it can be relieved by measures that range from aspirin to cortisone, to general anesthesia.

The general treatment is important. Rest periods and controlled active exercise periods are helpful. Recreational exercises such as golf and tennis are ideal. Walking is the best exercise. A sleep routine is helpful. Relaxation and mild medication are beneficial. Steinberg found Vitamin E effective in 115 cases of primary fibrositis. Physical therapy, which improves the local circulation, is helpful and acceptable to the patient. Small doses of amphetamine are useful. Atropine is often helpful for fatigue. Glycine may be beneficial.

Hickman claims that primary fibrositis is the first human deficiency condition which has been found definitely to respond to Vitamin E. This belief was strengthened by Moore's observation that the quantity of Vitamin A found stored in the liver is proportional to the amount of Vitamin E in the diet.

Fibrositis as a clinical entity has for many years been accepted although its pathological foundations rest upon the theories of Gowers, the equally unconfirmed histological studies of Stockman and the suggestion of Elliott regarding muscle spasm as a cause. Copeman quotes Stockman's definition of fibrositis as "a condition of chronic inflammation of the white fibrous tissue of the fascial aponeurosis, sheaths of muscles and nerves, ligaments, tendons, periosteum, and subcutaneous tissues, occurring in all parts of the body and giving rise to pain, aching, stiffness and other symptoms."

Nature of the Pain in Fibrositis. — Lewis, Kellgren and others pointed out that the pain in fibrositis generally has its origin in certain focal points from which the more general subjective pain complained of is referred according to a segmental plan. This referred pain may be situated at a considerable distance from its real origin.

These trigger-points, according to Copeman, which when palpable are termed "fibrositic nodules," are objective clinical entities which are tender and painful.

Etiology of Trigger-Points and Nodules. — It was observed by Copeman that the pain in the back which accompanies most pyrexial illnesses is of the same nature and pattern as in fibrositis. Although the pain disappears with the cessation of fever, the tender trigger-point may persist for long periods. These trigger-points can be reactivated by recurrence of fever. The nature of the lesion may be a recurrent edema painfully distending certain fat lobules in the deep subcutaneous tissues. Trauma and the direct action of cold can cause similar lesions or precipitate their activation.

Fibrositis Due to Edematous Changes in the Fibro-Fatty Tissues. — The frequency of the occurrence of "fibrositic" pain of the lower back in healthy young soldiers stimulated Copeman's interest in this subject.

The pain chart which evolved as the result of plotting the site of the trigger-points or painful nodules in Copeman's cases of lumbar fibrositis was found to outline the erector spinae muscles, the crests of the iliac bones,

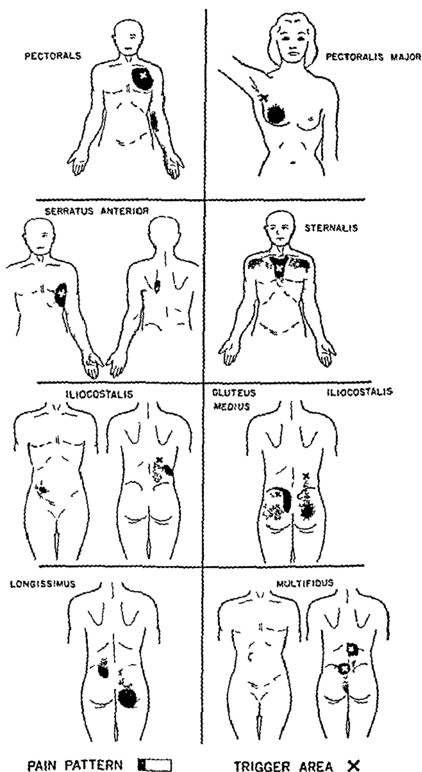


FIG. 163.—Trigger areas. (Travell and Rinzler, courtesy of Postgraduate Med.)

The Trigger-Point — A trigger-point is a small area which serves as a focal point of irritation set up in muscle, fascia, tendon or ligament in which pain sensations originate and from which they are dispersed in a definite anatomical pattern. A trigger-point is like a disaster area that sends out its own "S.O.S." alarms.

Ethyl chloride sprays or procaine injections break the pain spasm circuit in a manner analogous to switching off an electric light bulb by a wall button. The wall switch acts like the spray. Cutting the wire at some point in its course acts like an injection of novocaine.

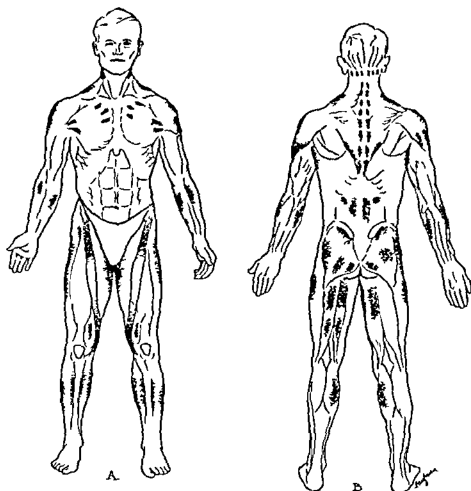


Fig. 165.—Most common location of myositis and fibrositis. (After Lange.)

The fibrositic syndrome consists of a muscular lesion with widespread reflex effects. From a myalgic focus usually near a musculo tendinous junction Kelly finds that pain, edema, deep hyperalgesia and stiffness or wasting of muscles extend over a well-defined area in a definite pattern. In 50 to 60 per cent of cases the focal lesion of fibrositis has a typical site. The original cause of the syndrome may be traumatic, infectious or rheumatic.

Injection and use of spray require a certain manual dexterity. Skill in hitting a trigger area increases with practice. Travell warns that this treatment cannot be done well in a hurry. The proper application of these

and the sacro-iliac joints As no evidence of pathological change could be found in the fibrous tissue or muscle in biopsy material, Copeman decided to examine the deeper layers of fat and found a curious herniation of a large lobule of distended fat through a defect in the deep fascia In a later biopsy of an easily felt and tender nodule from which widespread pain was being referred, he discovered by careful dissection that the nodule was an edematous-looking node of fatty tissue lying among superficial fat of the upper buttock, but with a pedicle which could be traced down to the layer of fat lying beneath the deep fascia

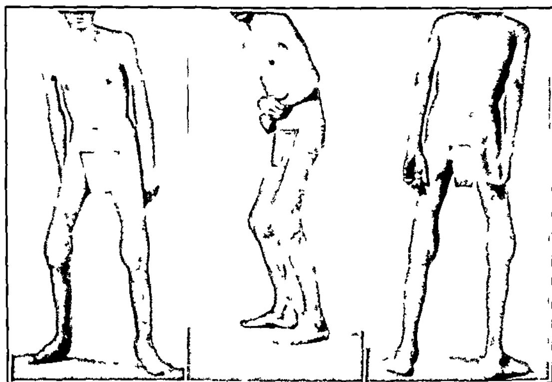


Fig 164 — Muscular rheumatism Multiple fibrositis (myositis) This is the type of patient whom Scott refers to as a spondylitic wreck (Courtesy of Dr Alfred Solomon)

Relationship of Panniculitis to Fibrositis —Where pain occurs in abnormally deposited fat it is referred to as panniculitis The condition was described by Stockman ' a chronic inflammation of the areolar tissue of the panniculus adiposus including the small nerves and blood vessels '

Copeman's investigations have shown that the pain originates as the result of edema and consequent distension of lobules of the abnormal fat deposits Panniculitis is most commonly encountered in the upper thoracic region the upper and outer aspects of the limbs around certain joints especially the knees elbows and ankles and some other sites Panniculitis is often associated with general obesity

Localization of the pain in cases of general obesity may be due to the less lobulated nature of the fat which is laid down elsewhere and also to the fact that in other sites such as the abdominal wall no fibrous fascia or capsule is present to limit the distension of the fat if it becomes edematous Herniation of fat lobules is common in association with obesity

Localized areas of fibrofatty tissue become edematous. Owing to the unyielding nature of the fibrous investment in which they are enclosed, painful tension is set up. These observations afford the explanation for the pain in a certain proportion of cases of fibrositis of the back and the gluteal region.

As the result of the work of Sir Thomas Lewis it has been accepted that the pain of fibrositis generally has its origin in certain focal points from which the subjective pain is referred according to a segmental scheme. Such referred pain may be felt at a considerable distance from its real source as is seen in cases of sciatica whose origin may be found in focal points situated in the lumbar or gluteal regions. These points are variously referred to as 'trigger-points,' 'myalgic spots,' or 'fibrositic nodules.' They are definite entities.

Sites of the Painful Spots.—Trigger-points have been mapped out in a large number of fibrositic patients and their situation carefully plotted. From above downward the situations in which a majority of these points cluster are: the point where the outer edge of the sacrospinalis muscle meets the posterior costal margin, a spot about 2[illegible] inches (7.4 cm.) above the iliac crest, which is the level at which the latissimus dorsi muscle often crosses the edge of the sacrospinalis muscle; another spot an inch (2.5 cm.) lower, and another at the edge of the sacrospinalis muscle just above the iliac crest. In the gluteal region these points may be found all along the crest of the ilium and for a distance of about 2 inches (5.1 cm.) below it. They may also be found along the sacroiliac junction where the deep fascia is attached.

Gorrell found that local injection of procaine solution cures muscle-fascia pain and often relieves pain due to deep-seated causes.

Results are good if trigger-points are found and carefully injected.

Pain, formerly supposed to be always protective in nature, actually may harm the organism by (1) preventing full function, *i.e.*, disability due to sprains; (2) causing other muscles to splint protectively the painful area; and (3) setting itself up as a nerve reflex, as an independent disease which persists long after the original cause has disappeared (Leriche).

Ethyl chloride spray and manipulation often relieve musculo-fascial pain; properly managed, they may cure a trigger point.

Technic of Injection.—Gorrell gives the patient a quick-acting sedative (pentobarbital sodium 1½ grains (0.1 Gm.) orally. This counteracts any possibility of procaine reaction and allays the nervousness of the patient.

After finding the trigger point, decrease the skin sensitivity by (*a*) spraying with ethyl chloride, (*b*) applying an ice cube wrapped in gauze to the skin or (*c*) keeping the skin under tension by spreading it apart with the finger tips of one hand.

Quickly jab the needle through the skin and into the subcutaneous fat. The fast introduction of a 22 to 24 gauge needle is almost painless (suggestion of Travell).

Slowly push the needle deeper through the insensitive fatty tissues until the patient complains of pain. Infiltrate with a small amount of 0.5 to 1 per cent procaine hydrochloride solution, until no tenderness is found on

methods is not a hit or miss procedure It is not psychogenic therapy Success depends fundamentally on a knowledge of the patterns of referred pain to which these trigger areas give rise A trigger area at a given site sets off a predictable constant pattern of referred pain Since the spot that one injects is not usually the same place where the patient complains of pain, one must know these patterns of referred pain in order to begin treatment Remote disease of the viscera can give rise reflexly to trigger areas in the skeletal muscles and to pain which is indistinguishable from that

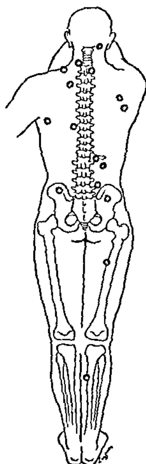


Fig 166 Common sites for the formation of sensitive fibrositic deposits (Mennell)

induced by trauma to the same group of muscles Furthermore visceral pain can be relieved by injecting those trigger areas concerned in its reference

Copeman and Ackerman report that fibrositis constitutes about 12 per cent of all medical cases seen in England Its pathologic foundations rest on the theories of Gowers and the observations of Stockman Copeman and Ackerman were struck by the high incidence of this disorder among a large body of highly selected young men They made several careful attempts to remove and examine nodules ' which had been palpable to the examining finger through the skin No areas of fibrosis were ever found however in this biopsy material which in every case included muscle

The syndrome may be initiated by many factors, and the relation of trauma, infection, exposure, fatigue, or vascular, metabolic, postural, occupational and psychogenic conditions have all been put forward.

The name 'fibrositis' was introduced by Sir William Gowers in 1904 to denote the inflammatory changes in fibrous tissue which were responsible for lumbago. Strong proposes the name 'myospastic syndrome' to replace the term 'fibrositic syndrome.'

A myotome for muscle biopsy was designed by Shank and Hoagland. It has been stated that there are 13 ligaments connecting one vertebra to another.

Strong lists his patients on the basis of history and symptoms into five groups, as persons who:

1. Have had backache as long as they can remember.
2. Get backache following rapid or sudden muscular movement.
3. Get backache without history of trauma.
4. Have no radiation of pain.
5. Have segmental neuralgias.

Graubard reports good results following the *intravenous infusion* of procaine for the control of pain in arthritic conditions. Intravenous procaine is said to have analgesic, sympatholytic and vasodilating, parasympathetic and anticontracting effects.

The administration of Vitamin C prior to the use of large doses of procaine increases resistance to the toxic side effects, particularly in patients in poor nutritional condition. Kovacs recommended the addition of 1 Gm. of sodium ascorbate, to each liter of 0.1 per cent solution of procaine.

The use of niacin and procaine hydrochloride seems to be helpful in the diagnosis of vasospasm. Steindler has demonstrated by his *novocaine* diagnostic test that radiating pain is not necessarily dependent on the direct compression of nerve substance but may be due to referred pain.

Diagnostic-Therapeutic Nerve Block.—The use of roentgenograms is indispensable to Pender and Pugh in performing diagnostic and therapeutic blocks for two reasons: (1) for more accurate placement of the needles and (2) as an objective record of the position of the needles at the time the anesthetic solution is injected.

Lundy employs roentgenograms to show the location of the needles with respect to bony landmarks for precision in technic. Subsequently, if it is recommended that certain nerves be cut, roentgenograms will assure the surgeon that the nerves in question were blocked.

Indications.—Among the situations in which diagnostic nerve block might be indicated are instances when, after careful physical examination, the cause of pain cannot be determined, or when the cause of pain can be recognized but cannot be either removed or cured.

When therapeutic block with alcohol or even adequate solution of phenol in water is used, Lundy finds it important to be able to check by means of roentgenograms the exact position of the needle. Injection of the solution is then carried out very slowly by what Lundy calls a "spot-wetting" technic in which he tries to wet the spot with only 0.5 cc. of the solution and to inject this quantity at ten second intervals and also to restrict the total quantity to as small an amount as possible. Usually, 2

palpating all around the needle at the marked trigger-point, or by moving the needle point from side to side

If deep tenderness is diminished but still present, slowly introduce the needle until another painful area is touched, and repeat slow infiltration of weak procaine solution

As soon as the transient dizziness caused by the anesthetic disappears, the patient should carry on any activities that increased the pain prior to the injection Reinjection is necessary if pain recurs or is still present at the end of forty eight hours

If the patient still complains of pain 50 mg of demerol hydrochloride may be added to the procaine solution

CHRONIC GENERALIZED FIBROMYOSITIS

Ornsteen was impressed by two features, the rigid spine and the myotonic state The patient complained that he was unable to bend his back and he had great difficulty in arising from a chair and starting to walk After several moments of effort, the spasm lessened and he was able to walk with less difficulty Much of his difficulty was experienced at the outset of a voluntary act involving the trunk and lower limbs

Ornsteen described and illustrated the sandbag like feel of the muscles of the back In the absence of evidence of organic central nervous system disease a diagnosis of myotonia acquisita was reluctantly suggested

MYOGELOSIS

Myogelosis means a congealing of muscle caused by a change in its colloidal state It is not a myodema or an inflammatory condition Myogelosis may be related to fibrositis or myositis or subcutaneous nodules except that the change occurs in the muscle cells It is difficult sometimes to find these masses and it is recommended that the skin be oiled before the examination is made The etiology involves exposure, violent muscle strain or acute infectious disease Many conditions called muscular rheumatism sciatica lumbago stiff neck neuralgia neuritis and muscle cramps are caused by muscle hardenings

A controlled study of pain relief by intravenous procaine was made by Keats and associates employing saline procaine hydrochloride, and morphine sulfate Saline relieved 20 per cent of fifty three postoperative patients procaine 40 per cent and morphine 70 per cent The addition of ascorbic acid permitted the administration of greater amounts of procaine than otherwise would have been possible without serious side-actions

Graham classifies fibrositis on an anatomic basis into intramuscular periarticular, tendinous or fascial bursal perineural fibrositis and panniculitis Classified on clinical grounds fibrositis has been considered as (1) primary —without demonstrable cause or sign of systemic disease and (2) secondary — a manifestation of disease such as infection or associated with various forms of arthritis or the results of strain or trauma exposure, occupation, postural and structural abnormalities

CHAPTER 27

THORACIC DISORDERS OF ORTHOPEDIC INTEREST

PAIN in the chest may indicate important visceral or somatic disease.

Breast Pain.—Smith describes the sensory nerves of the breast as gathered into the second, third, fourth, fifth and sixth intercostal nerves through the terminal branches and through the lateral cutaneous twigs of the lower four of these nerves. In addition, pain fibers in the second intercostal nerves have a common connection with the intercostobrachial nerve

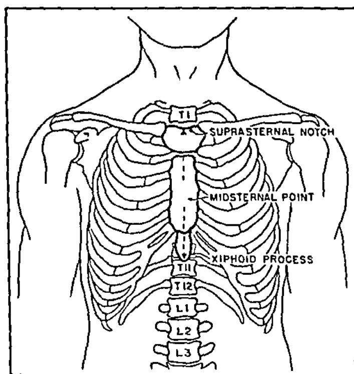


FIG. 167.—Diagram that depicts the location of the midsternal point. (Fuchs; courtesy of Radiography and Clinical Photography.)

of the brachial plexus. A few pain fibers may ascend in the second and third cervical nerves from the region of the clavicles. Sensory impulses from the medial brachial and medial antebrachial cutaneous nerves, as well as from the ulnar, may enter the spinal cord in the same segments as sensory impulses from the breast tissue innervated by the upper intercostal nerves. Diffusion of pain from the breasts passes around the chest and into the back, along the medial aspects of the arms and occasionally over the neck.

The skin is normally six to eight times thicker in the upper thoracic region than in most parts of the body. In the upper back, the fibrous projections between the corium and the deep fascia form a series of honey-

cc is the smallest quantity used and 4 to 5 cc is the largest in one spot For some patients who experience spontaneous remission of their pain for as long as a day, it may be desirable to inject *dolamine,* which is $\frac{1}{3}$ of 1 per cent each of *ammonium sulfate and benzyl alcohol,* or to inject procaine hydrochloride and ammonium sulfate in various concentrations, either together or separately Lundy has injected as much as 10 cc of 1 per cent solution of procaine hydrochloride without epinephrine in an attempt to block the ilio inguinal and ilio hypogastric nerves near the anterosuperior iliac spine After producing paresthesias of the original pain of which the patient was complaining he leaves the needle in place and injects as much as 10 cc of 5 per cent solution of ammonium sulfate in an effort to interrupt the conductivity of the nerve A few patients respond to the injection of ammonium sulfate and benzyl alcohol for varying lengths of time—some for hours to days to weeks and in a rare occasion, for months In these cases ammonium sulfate and benzyl alcohol seem to be more effective than a local anesthetic agent, and less hazardous than the use of alcohol or phenol

CHAPTER 28

CLAVICLE—STERNUM—RIBS—SCAPULA

CLAVICLE

The clavicle forms the connecting link between the thorax and the upper extremity. Winslow called it the "rudder of the movements of the shoulder blade."

The causes of clavicular lesions are congenital, traumatic, infectious and neoplastic. The chief congenital condition is absence of the clavicles, known as dysostosis cleido-cranialis. Injuries of the clavicle are fractures occurring during delivery, at birth, during childhood and adult life, and dislocations. The important lesions of the clavicle are osteomyelitis and tumors. The chief operations on the clavicle are those performed for osteomyelitis and resection of tumors and for ununited fractures and unreduced dislocations.

Usually clavicle fractures can be treated successfully by the application of a plaster-of-Paris cast to maintain backward thrust of the shoulder. The Funston splint is effective if there is little overriding of the fragments. The clavicular T splint which produces the knapsack position is satisfactory. Adhesive strapping may be used. When fracture is severe and cannot be reduced by posture, splinting, or strapping, open operation is required.

Tuberculosis of the clavicle is rare and should be treated by removal of all tuberculous tissue and packing the wound. If necessary, a bone graft operation may be performed.

The usual fracture presents few problems. However, some do not unite and require surgical reduction and fixation. The Kuntscher nail or thread wire are effective. Matthew's wire is quite popular. Subperiosteal resection is very effective. Phemister's operation is simple and leaves the bones intact, which is important in the settlement of compensation cases. It is deserving of a trial in old as well as recent dislocations.

Ununited Fracture of the Clavicle.—Pipkin reported a case that permitted evaluation of two possible forms of surgical therapy in the adult, viz: bone grafting versus excision, as this patient for a short time had a successful bone graft before it fractured and excision was elected.

A tardy case of shoulder-hand syndrome following ununited fracture of the clavicle was reported by Pipkin who excised the clavicle with excellent results.

Watson-Jones reported a case of tardy shoulder-hand syndrome following ununited fracture of the clavicle. Ghormley had one such case in his series of twenty nonunions reported from the Mayo Clinic. In his comment he states: "The patient who showed evidence of pressure on the brachial plexus also presented signs of interference with the venous circulation of

comb-like compartments which are filled with vascular fat. The axes of these "cells" are found to be parallel with the tension lines of Langer. This is particularly noticeable in the upper back area, and Copeman called this diamond shaped structure, the "dorsal fat-pad." It corresponds with the trapezius muscle.

When painful nodules are palpable they are seldom fibrous in nature. Biopsy discloses that the nodule consists of the fatty contents of one or more of these compartments, swollen and under tension. If an incision is made at right angles to the lines of tension in the skin, the wound will gape and the lobule will present itself above its surface. It is also shown by the *peau d'orange* appearance if the skin and subcutaneous tissues of an affected area are compressed laterally. Palpable nodules of this type can be "rubbed away" by means of deep massage.

Localization of Vertebral Levels and Internal Structures

(Fuchs, courtesy of Radiography and Clinical Photography)

Spinous Processes of Thoracic Vertebræ	*Internal Structures in Same Transverse Plane*
Second (2T)	Suprasternal notch, arch of aorta
Third (3T)	Root of spine of scapula, bifurcation of trachea
Fourth (4T)	Superior limit of heart
Seventh (7T)	Inferior angle of scapula, right arch of diaphragm
Eighth (8T)	Inferior cardiac border, left arch of diaphragm, junction of xiphoid process and body of sternum
Tenth (10T)	Cardiac orifice of stomach, superior border of left kidney, apex of spleen
Eleventh (11T)	Superior border of right kidney
Twelfth (12T)	Pyloric end of stomach, splenic flexure of colon, inferior border of spleen

Symptoms and signs depend on which of the three important structures are involved, namely, the subclavian artery, the subclavian vein, or the brachial plexus.

If one analyzes the anatomical structures through which the subclavian and axillary artery and vein must pass, it is evident that no single operative procedure can be successful in all cases of the shoulder girdle syndromes. A satisfactory "space making" procedure for the subclavian artery and vein and the brachial plexus can be developed by total resection of the clavicle, division of the scalenus anticus muscle, and mobilization of the subclavian artery downward.



Fig. 170. Two months after the insertion of the threaded wires. (Phemister; courtesy of J. Bone & Jt. Surg.)

Finally, not only by elimination of the aforementioned two anatomically fixed points is the artery lengthened into the axilla, but it is also lengthened after claviculectomy by the inward and forward movement of the shoulder girdle toward the chest wall, which further relaxes the pectoralis minor muscle.

The operation is carried out by an incision over the length of the clavicle with subperiosteal resection of the bone. Then the periosteum is completely and carefully removed to avoid injury to the subclavian vein. The scalenus anticus muscle is sectioned and the subclavian artery mobilized downward. Postoperative x-rays have shown no evidence of bony regeneration during the first six postoperative months. Function of the arms and shoulders has been excellent and, except for temporary aching discomfort in the shoulder areas in two heavily muscled men, no disability has been noted. No disfigurement has resulted from the procedure.

tenderness over the inner end of the right clavicle difficulty in breathing and pain on swallowing

The difficulty in breathing was aggravated by walking, which caused a crowing type of breathing It was practically impossible to breathe with the head erect Flexion of the chin on the chest seemed to give the greatest relief When put to bed he sat in the upright position with one or more pillows under the head to flex his chin on the chest

The x-ray examination of the shoulder girdle showed an upward posterior and medial displacement of the proximal end of the clavicle to the extent of about 2 cm There was one small fragment that was apparently broken off the superior medial corner of the clavicle There was also a slight in-

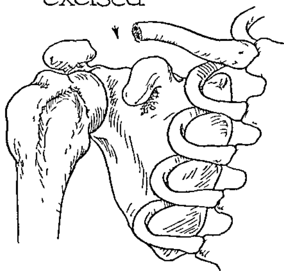


Fig 169 —Mumford has demonstrated that dislocation of the acromioclavicular articulation may be treated satisfactorily by excision of the distal third of the clavicle The recovery period is only three to four weeks (Courtesy Jour Bone and Joint Surg)

dentation of the right lateral margin of the trachea with a slight displacement toward the left side indicating an encroachment on the trachea A good result was obtained without using any means of internal fixation following open reduction

Tumors of the Clavicle — Tumors of the clavicle may be primary or secondary The primary tumors may be benign or malignant In a search of the files of the surgical pathological laboratory of the Johns Hopkins Hospital, Anderson found 46 lesions of the clavicle among 1700 bone lesions The lesions included 16 metastatic carcinomas 4 bone cysts, 4 Ewing tumors, 2 exostoses and 1 each chondroma giant cell tumor, chondroblastoma osteogenetic sarcoma and sclerosing sarcoma

Claviculectomy —In the operation of claviculectomy one should perform a complete periosteal dissection and remove the clavicle in its entirety

Symptoms and signs depend on which of the three important structures are involved, namely, the subclavian artery, the subclavian vein, or the brachial plexus.

If one analyzes the anatomical structures through which the subclavian and axillary artery and vein must pass, it is evident that no single operative procedure can be successful in all cases of the shoulder girdle syndromes. A satisfactory space-making procedure for the subclavian artery and vein and the brachial plexus can be developed by total resection of the clavicle, division of the scalenus anticus muscle, and mobilization of the subclavian artery downward.



Fig. 170.—Two months after the insertion of the threaded wires. (Lhermitte, courtesy of J. Bone & Jt. Surg.)

Finally, not only by elimination of the aforementioned two anatomically fixed points is the artery lengthened into the axilla, but it is also lengthened after claviculectomy by the inward and forward movement of the shoulder girdle toward the chest wall, which further relaxes the pectoralis minor muscle.

The operation is carried out by an incision over the length of the clavicle, with subperiosteal resection of the bone. Then the periosteum is completely and carefully removed to avoid injury to the subclavian vein. The scalenus anticus muscle is sectioned and the subclavian artery mobilized downward. Postoperative x-rays have shown no evidence of bony regeneration during the first six postoperative months. Function of the arms and shoulders has been excellent and, except for temporary aching discomfort in the shoulder areas in two heavily muscled men, no disability has been noted. No disfigurement has resulted from the procedure.

Costoclavicular Compression Syndrome.—Falconer and Weddell, reported 3 cases of intermittent compression of the subclavian artery and vein between the clavicle and the first thoracic rib. They referred to the syndrome as the costoclavicular syndrome, or compression of the subclavian artery or vein. They found that if normal shoulders are braced backward and downward, the space between the clavicle and the first thoracic rib is often narrowed or reduced, causing the radial pulse to be obliterated. Although a high percentage of normal persons were able to obliterate the radial pulse by bracing the shoulders downward and backward, when the results of this test were found to be positive in a patient having marked disturbance of the function of the subclavian artery and vein, they were able to show that this was associated usually with some abnormality of the thoracic inlet.

Falconer and Weddell estimated that in about 62 per cent of normal persons examined bilateral costoclavicular compression of the subclavian vessels could be demonstrated. One must be on his guard, therefore, not to advise operation on the basis of this test alone. In those persons who demonstrate symptoms and signs, which are explainable on the basis of costoclavicular compression, a course of conservative therapy is advised by MacGowan. The patient should avoid carrying a heavy pack on his shoulders, and he should strengthen the muscles by exercise to pull the shoulders away from the direction which produced his symptoms. If the conditions should become intractable, and particularly if features of obliterative arterial disease should be present, exploration of the supraclavicular fossa is advised. At operation the exact site of the compression should be determined. This is best done with the patient under local anesthesia. After the pathologic factor has been demonstrated if a portion of the rib is to be removed the patient may be put to sleep either with an inhalation or an intravenous anesthetic.

The costoclavicular syndrome may also cause neck pain and other symptoms due to compression of the subclavian vessels in the space between the first rib and the clavicle. X-ray examination may indicate smaller than normal space between the rib and clavicle on the affected side. In this syndrome compression of the subclavian vessels is lateral to the point of compression that occurs in the scalenus anticus syndrome and can be demonstrated by two maneuvers. In the first maneuver the patient assumes an exaggerated military position of attention and takes and holds a deep breath with the result that the radial pulse is obliterated on the affected side and a bruit can be heard just under the clavicle where the subclavian artery is being compressed. In the second maneuver, the same results occur when the arm on the affected side is raised high overhead. In these maneuvers the already small space between the first rib and the clavicle is further narrowed and the subclavian vessels compressed partially or completely.

This syndrome differs from the cervical rib and the scalenus anticus syndromes in that no abnormality of structure is involved and that the circulation in the extremity is normal when tested in a position of relaxed adduction but impaired with obliteration of the axillary artery when the shoulders are forced backward and downward.

THE STERNUM

The sternum consists of three parts, the manubrium, the body or gladiolus, and the xiphoid process. The upper border of the manubrium supports the clavicles while the costal cartilages of the first seven pairs of ribs articulate with the margins of the manubrium and body. The cartilages of the first ribs fuse directly to the sternum, but for the cartilages of the second to seventh ribs, there are present sternocostal cavities or joints with articular capsules. The manubrium articulates with the body of the sternum by a dense fibrocartilaginous symphysis at the level of the juncture with the second pair of costal cartilages. Anterior and posterior

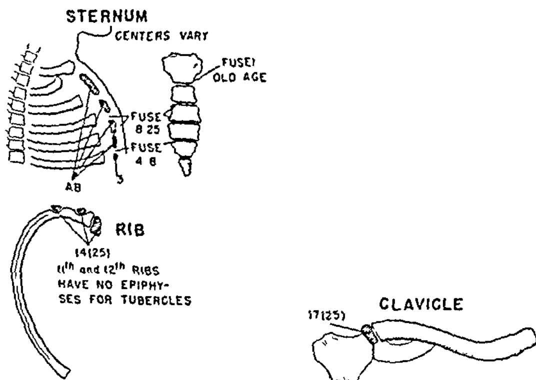


FIG. 171.—Time of appearance of centers of ossification. *AB* indicates that the ossification center is visible at birth. Figures in () give approximate time of fusion. (Golden, *Roentgenology*, courtesy Nelson & Sons.)

chondrosternal ligaments extend from the ends of the costal cartilages and diverge fanwise on the sternum to interweave with those from the opposite side. This layer, which ensheathes the sternum in front and behind, is called the membrana sterni. Anteriorly, the sternum is covered by the pectoralis major, sternomastoid and rectus abdominis muscles of each side. Posteriorly, the sternohyoid, sternothyroid, transversus thoracis and diaphragmatic muscle fibers are attached.

The sternum supplies points of attachment for the ribs, clavicles and sternocleidomastoid muscles. The sternum is a natural chest protector for the lungs, mediastinal structures and great vessels. However, when it is "bashed in," it injures the lungs and may cause a fatal trauma.

Injuries to the sternum are depression, fracture, and dislocation "Cave in" or "stave in" injuries are common in industry and in auto accidents In non fatal injuries traction can be applied to the sternum by means of towel clips placed around or through one or more ribs for over-thoracic suspension

Fractures of the Sternum —Fractures of the sternum are rare because of the mobility and elasticity of the thorax While they may be produced by indirect violence and by muscular action they are usually caused by direct violence such as crushing injury, a blow or a fall They occur most frequently in automobile accidents in which the chest is thrust against the steering wheel

The fracture may be in the manubrium the gladiolus or the ensiform but as a rule is transverse at the junction of the manubrium with the gladiolus There is always danger to the lungs and pleura In children a dislocation may occur between the manubrium and gladiolus Anteroposterior lateral and oblique roentgen projections should be made

The treatment is similar to that recommended for fracture of the clavicle *It is important to hold the shoulders backward and upward Corkscrew* reduction of a depressed fracture requires great caution

The manubrium is usually displaced anteriorly Stuck observed four cases of fractures of the sternum

There are factors which interfere with accurate diagnosis of this condition (1) generally there are accompanying injuries (fractures of the vertebrae injury to the head or fractured limbs) which divert attention from the sternum (2) roentgen ray visualization of this bone is exceedingly difficult and (3) roentgenograms of the sternum are unwarranted except in cases in which a specific injury is suspected

Mechanism of Fracture —Fractures of the sternum are produced by *direct or indirect injury and follow direct blows to the thorax crushing* injuries of falls Force may also be transmitted laterally through the clavicles and produce fracture or in sudden flexion of the trunk the chin may strike the manubrium and produce it The fractures due to indirect injury are produced by abnormal muscular action A fall backward in which the torso is hyper-extended may produce undue strain through the sternomastoid muscles above and the rectus muscles and diaphragm below However direct injury is the greatest source of fracture

The commonest site of fracture is near the juncture of the manubrium and the body where the bone is thinnest and where skeletal attachments are most rigid Fractures of thoracic vertebrae ribs or of the upper extremities are common findings Compound injuries are rare Possible complications include rupture of the internal mammary arteries with resulting hemothorax partial obstruction of the trachea traumatic pneumonia or laceration of the pericardium

Diagnosis —Fracture of the sternum is diagnosed readily by the presence of deformity crepitation sharply localized pain and ecchymosis The thorax is fixed breathing is mainly abdominal the shoulders are dropped forward and the patient holds his head rigidly to prevent torsion through the sternomastoid muscles The suspicion of fracture is corroborated by lateral or oblique roentgenograms which will reveal detail of the bone In

anteroposterior roentgenograms of the thorax, the sternum is heavily overshadowed by the spinal column and mediastinum. Pfahler recommended the lateral position as most desirable, with the patient standing, his hands behind his back, the shoulders forced backward as far as possible. The exposure is made during full inspiration. Kohler found that the sternum is visualized by the oblique position from the right posteriorly to the left anteriorly.

Although rare, fractures of the sternum probably occur more often than is realized or discovered. They are not diagnosed because serious complicating injuries often accompany them and because they are difficult to visualize with the roentgen rays. Anatomically, the manubrium is rigidly

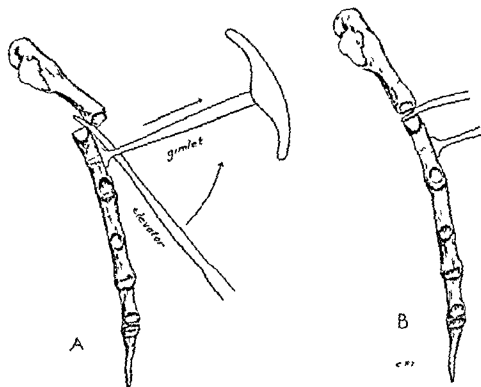


Fig. 17. — Open reduction of fracture of sternum. *A*, Periosteal elevator between fractured surfaces; gimlet screwed into body of sternum. *B*, Reduction accomplished by forward traction on gimlet and leverage with periosteal elevator. (Campbell: *Operative Orthopedics*, courtesy of C. V. Mosby Co.)

attached to the vertebral column through fusion with the first pair of ribs. Elsewhere the attachments are more elastic and resistant to fracture.

This injury is best treated by rest in bed, local heat and moderate hyperextension. Recovery is usually prompt and complete. Steindler finds that even though the fracture cannot be reduced manually and a definite deformity can be palpated, open reduction is seldom indicated. The appearance of the bony prominence constitutes the chief reason for operation. Union of the fracture in malposition has no serious consequence.

Technic. — An incision three to four inches in length is made in the midline over the prominence down to the periosteum. A corkscrew is inserted into the body; a small periosteal elevator is placed between the fragments,

and the fractured surfaces are levered and pulled into normal relation This procedure may be attended by considerable shock

Dislocation of the Sternum —The mechanogenesis of this dislocation is a combination of jackknifing and compression In one case reported in the *Journal of the American Medical Association* a few years ago a man was struck by a truck while he was bent forward The truck forced him backward against a pillar, thereby compressing the lower portion of his chest and his abdomen The patient felt a loud snap in his chest followed by severe pain over the 2d and 3d ribs While the examiner s hand was compressing this area inward the patient demonstrated the position in which he stood when he was struck As he did so the corpus slipped behind the manubrium and upward, demonstrating a complete dislocation of the joint, the 2d rib remaining attached to the manubrium The pain accompanying the dislocation caused a gasp with quick erection of the patient s body and reduction of the dislocation

Sternal Epiphysitis —The sternal epiphysis unites during the twenty-fifth year the lateral epiphysis in the twentieth year The sternal epiphyses do not always completely ossify the lateral epiphysis may not ossify at all Anomalies of retardation or acceleration occur These anomalies may be confused on roentgenograms with fractures Aneurysm of the aorta may cause necrosis of the sternum

Diseases of the sternum are osteomyelitis and gonococcus infection at the sternoclavicular joint Tuberculosis of the sternum is rare My recommendation for treatment is curettage and packing Operations on the sternum include drainage curettage and fusion of the sternoclavicular joint Other important features are (1) source of biopsy material bone and blood cells (2) tumors, (3) injection of fluids and (4) antibiotics

THE RIBS

Anomalies include cervical ribs, absence of ribs and supernumerary, forked and fused ribs

Cervical Ribs —LeDouble recognized the following varieties (1) the complete cervical rib extending from the 7th cervical vertebra to the manubrium and independent in all its parts from the clavicle as well as the thoracic rib (2) the type in which the cartilaginous portion of the cervical rib is fused with that of the 1st thoracic (3) the type in which the midportion is replaced by fibrous bands

Anatomy —The ribs are elastic arches of bone which form a large part of the thoracic cage On the inferior border of the shaft is a groove for the intercostal vessels and nerve Within the groove are seen numerous small foramina for nutrient vessels which traverse the shaft The blood supply of the ribs is derived from the internal mammary artery which supplies the anterior intercostal branches and from the thoracic aorta

The ribs are of interest because of fractures primary and secondary tumors and such infections as tuberculosis

The chief injuries of the ribs are fractures and dislocations Chief defects are absence of ribs supernumerary ribs forked and fused ribs and neoplasms

The chief tumors are multiple myeloma and metastatic carcinoma. Benign tumors of the ribs are exostoses, myelomas, chondromas, osteochondromas, giant cell tumors and osteitis fibrosa cystica. Primary malignant tumors are sarcomas and myelomas. Secondary tumors of the ribs originate in the breast, uterus, prostate or adrenals.

The intercostal muscles are important because of their involvement by neuralgia and radiculitis. Herpes zoster produces pain of great diagnostic interest. Tuberculosis of the ribs is uncommon. My recommendation for localized tuberculosis of the ribs is resection and antibiotics.

Fractures of the Ribs.—Fractures of the ribs may be caused by direct or indirect violence. One or more ribs may be fractured, and multiple fractures may occur in a single rib. The symptoms are pain in the chest, difficulty in taking a deep breath and tenderness on palpation. Rib fractures are often difficult to see in the roentgenogram, but compression on any part of the thoracic cage usually reveals the painful spot.

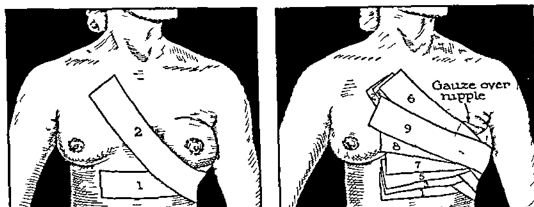


FIG. 173.—Adhesive strapping of female chest. (Courtesy of Johnson & Johnson.)

A series of 279 cases of fractured ribs was reported by Hinton and Steiner, the automobile being responsible for more than three times as many of these injuries as all other factors combined. The fifth and ninth ribs are the ones most frequently fractured.

Adhesive strapping of the chest limits respiratory excursion and gives the lungs a rigid object against which to work. Two-thirds of the circumference of the body must be included in the taping, and care must be taken not to increase any over-riding by tight strapping.

Although the ribs are almost constantly in motion because of respiratory movement, rib fractures usually unite in a comparatively short time.

In old fractures with over-riding of rib fragments, resection of the overlapping portions may be necessary.

Description of Chest Strapping.—The patient stands with his affected side nearer the physician. The tender area is localized by gentle circumferential compression and finger point pressure. A wide area is shaved if necessary and painted with compound tincture of benzoin or sealskin. The hair of the axilla and the edge of the axillary fold are protected by a pad. The nipple of the male should be covered by a small pad. The adhesive should be 1 or 2 inches wide and applied as shown in Figure 171.

No one strip completely encircles the thorax, but each covers about two thirds of its circumference When the adhesive is fully applied a man's vest is put on In a few days one removes the adhesive and applies the vest alone

Radiation therapy should be employed in all cases of malignancy

Vest Compression Support for Fractured Ribs and Some Other Thoracic Conditions —I have used an adjustable vest for twenty years especially on women and hairy-chested men The conditions where the vest is of value are those where deep breathing, laughing coughing sneezing, or straining at stool cause pain in the chest

My experience has been chiefly in cases of fractured ribs, especially where overlap was present

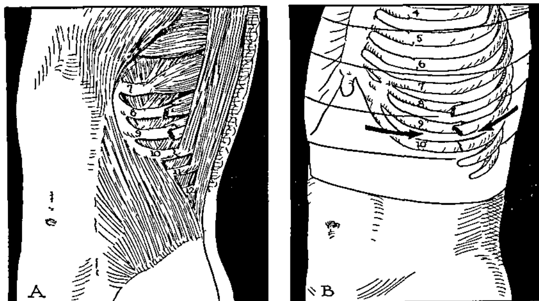


Fig 174 —Fractures of the 8th 9th and 10th ribs on the left side with over riding of fragments (Courtesy of Johnson & Johnson)

The method is applicable to many conditions such as Polioparalysis (1) to prevent muscle imbalance and scoliosis (2) as support where chest muscles are weakened especially in respirator cases

The advantages of the vest are (1) availability, (2) adjustability—during day and night for meals for work while sitting and sleeping (3) removability, no pain in removal (4) ease of care of body hygiene

Equipment required a man's vest or a fabricated vest and 6 or 8 safety pins Technic Regulate the size by means of safety pins inserted in the back of the vest Usually all that is required is to overlap the back of the vest and insert 6 pins then apply the vest and button in front Another pin can be used at any point where snugness is required especially at the top and bottom in front

A triangular sling may be added to prevent the drag of one or both upper extremities on the thoracic cage or shoulder girdle A loop of strong material may be sewed on the front of the vest and the patient's sleeve may be secured thereto by a safety pin or another loop or tab

One of my female patients bought a riding jacket and pinned it in several places to make a perfect support.

A piece of rib at the fracture site may be as pointed and sharp as a knife and may produce any of the complications of penetrating wounds of the chest. The most important of these are pneumothorax, hemothorax and subcutaneous emphysema. Aspiration of intrapleural air, and of blood when symptoms of pressure occur, is essential. Steinbach advised strapping only for patients with paradoxical respiration.

Cough Fractures of Ribs.—Cohen observed a number of cases of "spontaneous" fracture of ribs occurring in tuberculous subjects.

Cohen explains the production of these fractures on the basis of a violent and abnormal action, probably associated with asymmetrical posture producing uneven action on the ribs, occurring during the violent expiratory effort of a cough or sneeze.

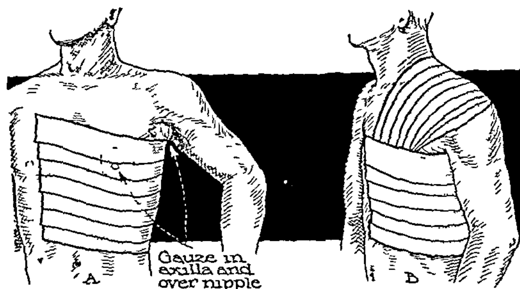


FIG. 175.—Adhesive strapping of left side of thorax. (NOTE: Shoulder strapping irrelevant.) (Courtesy of Johnson & Johnson.)

Cough Fractures in Late Pregnancy.—Rib fractures due to cough alone, or with an added factor of shearing stress from simultaneous action of other muscles, have been described.

Zoppi, in 1936, recommended the injection of procaine at the site of the fracture of a rib, procuring immediate relief of pain, and the patient's ability to cough, move, and breathe deeply returned at once.

Other writers had previously recorded the alcohol injection of intercostal nerves posteriorly in order to anesthetize a wider area for serious injury to the chest wall. Labat described intervertebral block using procaine and alcohol, and Latteri described alcoholization of intercostal nerves. Grieco, and Rovenstine and Byrd produced intercostal block with alcohol. Repeated injections daily may be necessary, to provide continuous relief from pain.

In many cases radiographs will not show a fractured rib even when such a fracture is clinically present and can be felt.

A hematoma entered by the needle does not indicate absolutely that there is a fracture, although such a hematoma is constantly present with a fracture Often the injecting needle can clearly detect the fracture

A bilateral fracture of the first rib may result from a blow on the back Such fractures may occur from a fall which causes the body to jack knife sharply Rib fractures usually heal within a period of six weeks regardless of immobilization

The Colemans found that 10 to 20 per cent of patients with fractured ribs associated with pleural or lung complications, die of their injuries

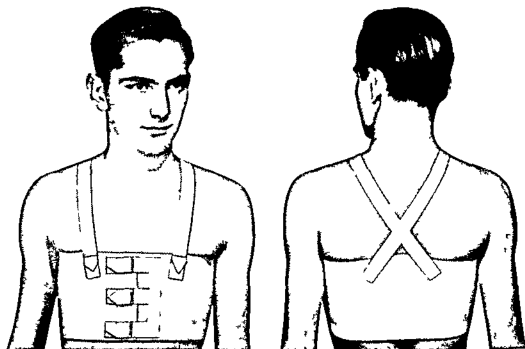


Fig 176 —Rib belts (Courtesy of United States Mfg Co)

Incomplete fractures and complete fractures unattended by rupture of the periosteum seldom show either displacement or injury to the pleura or lung in some instances and may not be demonstrated by x-ray examination Overlapping of fragments is common in fractures involving multiple ribs

Irrespective of the mechanism of shock the establishment of a clear air way is the first step in correcting altered physiology Recovery from shock is aided by aspiration of the blood or air from the pleural cavity

Lattern recommended injection of intercostal nerves with alcohol for the relief of chest wall pain Injection of 1 or 2 per cent solution of novocain will relieve the pain for a period of from two to four hours in the majority of cases with simple rib fractures however, repeated blocks are often necessary Intercostal nerve block relieves pain aids in establishing an effective cough, improves the ventilatory capacity of the lung and promotes bronchopulmonary drainage Whenever pain is a factor in the treatment of fractured ribs, the Colemans recommend blocking of the intercostal nerves Complete and multiple rib fractures with and without complica-

M PECTORALIS MINOR

STERNUM

M PECTORALIS MAJOR

A

Fig 177 —Surgical approach to fractures of upper five ribs anterior to the midaxillary line (Coleman and Coleman courtesy of Surg Gynec & Obst)

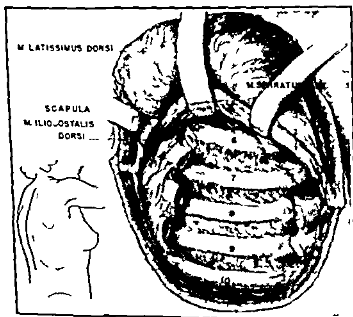


Fig 178 —Surgical exposure of anterior and posterior fractures involving ribs six through ten The musculocutaneous superior flap is reflected upward (Coleman and Coleman courtesy of Surg Gynec & Obst)

tions in which a more logical attack is needed to relieve pain, stabilize the chest wall correct deranged physiology, and alleviate or prevent complications Good anesthesia antibiotics, and chemotherapy have made it safe and practical to approach the sites of rib fractures deliberately and stabilize the thoracic cage

Indication for Wiring of Rib Fractures —External skeletal traction Drinker respirator, and strapping of the thorax have been used to correct paradoxical chest wall motion Eleven patients with multiple rib fractures associated with varying degrees of shock and paradoxical chest wall motion have been subjected to internal fixation of the fracture sites by wire Pain was immediately abolished The fragments must be fixed in two planes

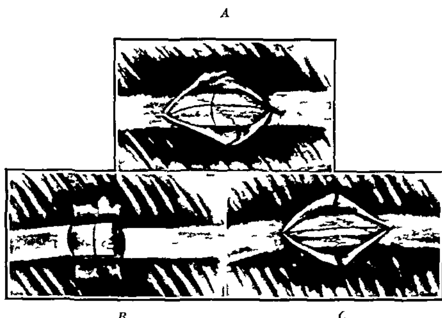


FIG 179 —Internal fixation of fractured ribs *A* On end wiring of oblique fracture accompanied by a circumferential wire *B* Fixation of transverse fractures by wiring overlapped fragments *C* Intramedullary pegging of transverse rib fractures accompanied by on-end wiring preferred method of fixation in this type of fracture (Coleman and Coleman courtesy of Surg Gynec & Obst)

The treatment employed in the management of fractured ribs consisting principally of strapping the chest or other methods of immobilization may be harmful Intercostal nerve block with novocain gives temporary relief of pain

Severe pain, paradoxical motion of the chest wall instability of fracture fragments of the lower six true ribs or pleural and lung complication are imperative indications for internal fixation of fractured ribs by wire

Stable fixation of transverse or oblique rib fractures can be attained by fixing the fragments with wire or with wire and a bone peg The results of wiring fractured ribs by the Colemans have been extremely favorable

Hammock and Arbuckle reported ten patients who were treated with gamma radiation for cancer of the breast and who subsequently developed fractures of the ribs These patients have remained free of clinical evidence of cancer for periods ranging from four to nine years

Cartilaginous Tumors of Ribs and Sternum —Cartilaginous tumors of the ribs and sternum are prone to malignancy O'Neal and Ackerman advise adequate radical resection of the ribs and sternum with removal of long segments of the bone of origin, the periosteum, adjacent muscle, underlying pleura, and adjacent bony structure

These tumors fit the histologic diagnosis of malignancy in cartilaginous tumors as established by Jaffe and Lichtenstein The tumor may be single or multiple and too much dependence cannot be placed on roentgen examination as great difficulty is experienced in obtaining adequate views, particularly in small tumors of the sternum and those at the extreme anterior ends of ribs In doubtful cases, aspiration or incisional biopsy is in order

Tuberculosis of the Ribs —Tuberculous involvement of the ribs which is usually easily demonstrable roentgenologically may also furnish a clue to the presence of vertebral disease In 18 per cent of Auerbach's cases of Pott's disease, one or more ribs were also involved

In all operations on ribs the anesthetist should be prepared to use positive pressure Intratracheal instillation is preferred by some surgeons Resection of ribs is simple but the surgeon must be careful to avoid puncturing the pleura Antibiotics are effective

THE RIB JOINTS

There are twenty-four joints, called the costovertebral articulations formed by the juncture of the heads of the ribs with the sides of the spine Besides these there are twenty joints called the costotransverse articulations, formed by the angles of the ribs and the outer parts of the transverse processes of the upper ten thoracic vertebrae According to Goldthwait these joints are at an added disadvantage or handicap in that other joints have periods of rest after periods of activity while rib joints (unless they become ankylosed from disease) never rest entirely so long as respiration is sustained and life exists

Since there is a nerve which leaves the spine just at the level of every vertebra adjacent to the head of the rib it is readily understood how irritation of these nerves occurs Also, since there is a sympathetic ganglion connected with the nerve adjacent to the head of the rib some circulatory disturbances find their explanation in irritation of this ganglion

Brown added that when it is realized how close to the bone the nerve is and how taut the ligaments and capsule of the rib joints must be in the drooped position it is possible to understand how torsion of the ribs in faulty body mechanics may cause acute strain on these nerves or how slight a pressure over a long period may cause interference with the blood supply to these nerves A great many obscure thoracic and abdominal symptoms can be explained on the basis of pressure on the nerve roots

Sufficient anatomical and clinical evidence exists to show that in the drooped position of the thorax seen in faulty body mechanics it is possible for pressure or stretching of the intercostal nerves to occur with radiating pain along the nerves involved This pressure may come from acute or chronic strain of the costovertebral or the costotransverse joints

tions, in which a more logical attack is needed to relieve pain, stabilize the chest wall, correct deranged physiology, and alleviate or prevent complications. Good anesthesia, antibiotics, and chemotherapy have made it safe and practical to approach the sites of rib fractures deliberately and stabilize the thoracic cage.

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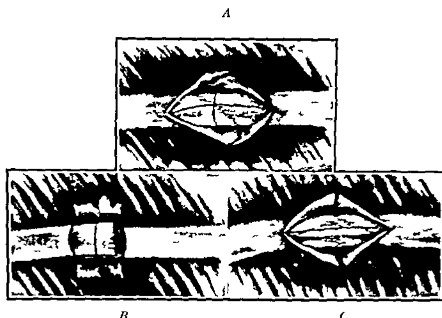


FIG. 179. Internal fixation of fractured ribs. A. On-end wiring of oblique fracture accompanied by a circumferential wire. B. Fixation of transverse fractures by wiring overlapped fragments. C. Intramedullary pegging of transverse rib fractures accompanied by on-end wiring; preferred method of fixation in this type of fracture. (Coleman and Coleman, courtesy of Surg. Gynec. & Obst.)

The treatment employed in the management of fractured ribs consisting principally of strapping the chest or other methods of immobilization may be harmful. Intercostal nerve block with novocain gives temporary relief of pain.

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Hammock and Arbuckle reported ten patients who were treated with gamma radiation for cancer of the breast and who subsequently developed fractures of the ribs. These patients have remained free of clinical evidence of cancer for periods ranging from four to nine years.

The defect consists of an upward displacement and rotation of the scapula, is usually unilateral and may be associated with other deformities There may be bony, cartilaginous or fibrous connections of the scapula with the vertebræ, usually the 4th to the 7th thoracic The "omovertebral bone" is a bony prolongation from a transverse process or a detached bone jointed at either extremity, running from the median border of the scapula to one of the lower cervical vertebræ Defective ribs, vertebræ and muscles may be found The neck is usually short and thick Abduction of the arm is restricted Torticollis may be present Scoliosis is found in 50 per cent of cases, and in 25 per cent there is an attachment to the vertebral column The clavicle is frequently aplastic or shortened by increased curvature

The diagnosis is confirmed by roentgenograms The prognosis for improvement is poor without operation, and only fair with operation

The operation advised by Schrock consists of subperiosteal freeing of the entire scapula which is then displaced downward and its angle secured in a muscle pocket The suprascapular nerve and the artery are the only ones seen The incision is curved from the midsuprascapular region about 1 inch lateral to the medial margin of the scapula to 2 inches below the inferior angle The deeper incision is carried through the cartilaginous medial margin of the scapula with subperiosteal separation of the rhomboids, serratus magnus and subscapularis muscles Similar subperiosteal elevation is made of the infraspinatus, the teres major and minor muscles, completely freeing the inferior angle and lower two-thirds of the axillary border The same procedure is applied to the insertion of the trapezius on the spine of the scapula, to the supraspinatus muscle and to the structures of the superior margin of the scapula, special care being used at the suprascapular notch The chondro-osseous bridge from the vertebræ to the supero-medial margin of the scapula is removed as completely as possible The margins of the scapula are freely removed The supraspinous portion is resected with much of the spine of the scapula, if at all prominent When the shoulder cannot be brought back freely, an osteotomy of the base of the acromion is performed Suture of the muscle layers is done anatomically, with special care in the triangular area between the trapezius, infraspinatus and rhomboid muscles Shore recommended resecting the upper margin of the scapula and the adventitious bone

Whitman's operation for Sprengel s deformity and paralysis of the serratus magnus muscle consists of a subperiosteal dissection of the vertebral and superior borders of the scapula Four holes are drilled in the scapula and four more in the spinous processes Fascia latæ is used to secure the replaced scapula to the vertebræ In Whitman's first case traction on the brachial plexus produced severe symptoms (A similar operation was described for droop shoulder, except that the shoulder was suspended)

Winged Scapula—Scapula Alata —Winged scapula (scapula alata) means unusual prominence of the scapula It may be unilateral or bilateral, due to injury to the serratus magnus or to its nerve, the long subscapular nerve of Bell, as it passes through the scalenus muscle Winged scapula may be due to rupture of the attachments of the scapula The serratus magnus may be weakened or paralyzed by involvement of the long thoracic nerve Ridlon and Berkheiser reported the case of a woman, who, during

Goldthwait based his treatment of affections of the rib joints on the anatomical and mechanistic situation Since the chest is constantly in motion during respiration, fixation in connection with disease is more difficult in the rib joints than in other joints

Absence of Some Ribs —A distinction should be made between the partial defects of ribs and sternum which are comparatively common, and the total defects of one or more ribs which are extremely rare Both partial and total absence of ribs are invariably associated with other deformities of the skeleton The absence of the costal element or its malformation or fusion always finds a corollary in errors of segmentation or differentiation of the spine

Anomalies of the Muscles —Not infrequently defects of the muscles of the thorax accompany defects of the ribs The pectoralis muscles are often underdeveloped or even lacking Weakness due to lack of muscle fibers is sometimes found in the serratus anterior muscle the lower portion of the trapezius and upper portion of the long muscles of the back

Congenital Funnel Chest —This appears to be similar to the condition often seen in rickets It may be due to intra-uterine malposition or to obstruction of the breathing passages during early life

THE SCAPULA

In an essay on the anatomy physiology pathology and therapy of congenital elevation of the scapula Huc emphasized the intimate relationship between the clavicle the shoulder blade and the thorax The upper margin of the shoulder blade corresponds to the second rib that is at this level *gin of the shoulder blade corresponds to the second rib that is at this level* between the second rib and the omo scapular angle the apex of the axilla is located The thoracic dome thus penetrating into the scapular area belongs to the supraclavicular region It really forms the floor of the supraclavicular fossa

The movements of rotation of the shoulder blade pivot around an axis situated in the infraspinous fossa They are brought about by displacements of the clavicle this bone being according to Winslow the rudder of the movements of the shoulder blade The amplitude of the movements of the scapula depend upon the length of the clavicle

The pathological modifications of the adaptation of the shoulder girdle to the thorax may be due to skeletal or to muscular factors The muscular lesions or paralyses are usually evident

The malformations of the shoulder blade consist chiefly of hypoplasia Hypertrophy of a part of the skeleton is exceptional and rarely isolated Scapular hypoplasia isolated or associated with other deformities but without elevation of the shoulder is frequently seen causes no functional disturbance

Sprengel's Deformity —Congenital elevation of the scapula or Sprengel's deformity has been called undescended scapula' by Schrock who collected 132 cases not previously reported At about the ninth week *in utero* the scapula begins to descend from the neck to the thorax Constriction of the fetus amniotic adhesions supernumerary structures or exostoses interfere with the descent of the shoulder girdle and cause primary arrest of development of the scapula

The causes of scapular disturbances are congenital, traumatic, infectious lesions, paralysis and new growths The most important congenital defect is Sprengel s deformity or elevation of the scapula Next in importance is winged scapula or scapula alata The chief acquired lesions are due to injury (chiefly fracture), paralysis (poliomyelitis and subscapularis nerve paralysis), and disease

Osteomyelitis, the most important disease of the scapula, may resemble a neoplasm Tumors of the scapula may be primary or secondary The primary tumors may be benign or malignant

Fig 180

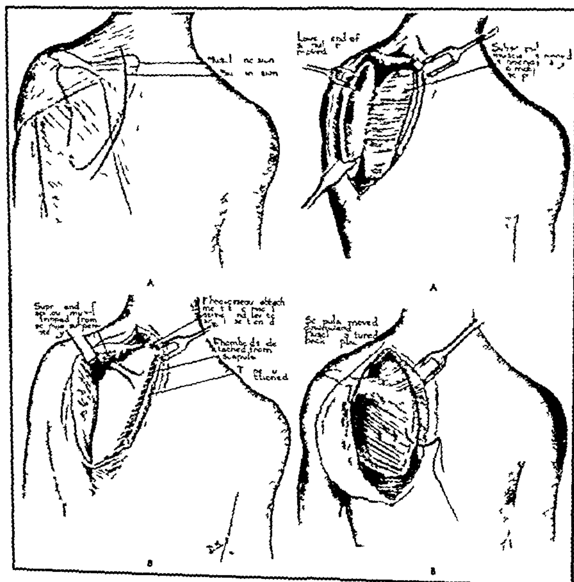


Fig 181

Fig. 180 —Release of scapular mu cles for congenital elevation of scapula (Sprengel s deformity) Operation of Schrock (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

Fig 181 —Operation of Schrock (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

delivery, pulled so vigorously on straps fastened to the foot of the bed that paralysis of the long thoracic nerve occurred resulting in a winged scapula. Delayed traumatic serratus paralysis may occur several days after a mechanical trauma to the muscles.

The scapula may be thrown out of action by paralysis of the muscles controlling its movements, by damage to their nerve supply, and by a direct injury. The trapezius derives its nerve supply from the spinal accessory and the 3d and 4th cervical nerves. The serratus magnus is supplied by the posterior thoracic nerve. It is most commonly injured in the neck by direct pressure, as in carrying heavy, sharp cornered objects, by blows on the neck and shoulder, or by muscular strain which produces a compression neuritis. The serratus magnus fixes the scapula when the arm is raised above the horizontal, in front of the patient. The rhomboids are the opposing muscles. Prognosis depends on the maintenance of muscle tone until nerve regeneration occurs.

The most valuable non-surgical measures are physical therapy, use of a direct current and splinting. Unless the reaction of degeneration is complete and the disability of long standing the integrity of the muscle should be maintained by exercise with appropriate applications of electricity.

The scapula must be maintained in its normal position with the aid of apparatus.

Page recommended drilling three holes in the vertebral border of a flail scapula and securing it to the 8th rib by means of fascia. Steindler considered the trapezius, serratus and the latissimus dorsi the important muscles. He questioned the advisability of anchoring the angle of the scapula. Nove-Josserand and Pouzet secured a flail scapula by means of a bone bolt made from the rib at the level of the spine of the scapula.

For both congenital elevation of the scapula and paralysis of the serratus magnus muscle A. Whitman recommended the following operation. An incision is made from the tip of the acromion process inward and downward to the superior angle of the scapula and then down its vertebral border. The periosteum is incised and it and the attached muscles are stripped back, thus exposing the superior and vertebral borders of the scapula. Four holes are then bored through the scapula with a drill, one at the superior angle, one at the junction of the spine and vertebral border, one in the middle of the vertebral border and one at the inferior angle. The spinous processes of the 4th, 5th, 6th and 7th thoracic vertebrae are then subperiosteally exposed as for spinal fusion. They are similarly pierced with a drill. Four strips of fascia 8 inches long and ½ inch wide have in the meantime been removed from the thigh by an assistant. These are passed through the corresponding holes in the scapula and spinous processes and while the scapula is drawn downward and inward with sharp retractors, the strips are tied under tension providing satisfactory correction of the deformity. The periosteum of the spinous processes and the scapula is then sutured over with the fascial strips. The muscles are sutured in place, the subcutaneous tissue closed with plain catgut and the skin with silk. A shoulder spica is then applied holding the arm abducted 45 degrees beyond a right angle. The spica is retained for three weeks when the top is removed and active motion started. At the end of eight weeks the patient is allowed full use of the extremity.

of the ribs, (7) tuberculosis or syphilis of the ribs or scapula They classified the causes as (1) changes in the bony structure of the under surface of the scapula or of the wall of the chest, (2) changes in the musculature intervening between the scapula and the wall of the chest (3) changes in bursæ normally or abnormally present between the scapula and the wall of the chest The tubercle of Luschka is a pea sized bony or fibrocartilaginous elevation located on the anterior aspect of the superior angle of the scapula It is usually covered by a bursa

The treatment of scapular lesions depends on the cause of the disorders Non-operative treatment consists of rest, local applications, physical therapy and supports (including plaster-of-Paris, airplane splints the Taylor spine brace and the Lunsten brace) Operations performed on the scapula include incision, curettage, anchorage of the scapula, and arthrodesis of the shoulder

THE SCAPULOCOSTAL SYNDROME

In the scapulocostal syndrome of adults with round shoulders and a drooping shoulder girdle there may be pain in the back of the neck but the main complaint usually is of deep shoulder pain and a definite trigger-point may be found beneath the upper medial angle of the scapula

Michele Davies, Krueger and Lichtor regard the scapulocostal syndrome as a clinical entity which may simulate a wide variety of conditions Thirty per cent of all individuals in the middle-aged group who presented shoulder complaints, either traumatic or nontraumatic, were found to have the scapulocostal syndrome

Michele and associates consider fascitis or fibrositis as responsible for the symptoms of this syndrome The pain distribution is reflex in type The most significant finding is a definite trigger-point beneath the upper medial angle of the scapula in conjunction with the posterior chest wall This point may be determined by one of three clinical tests

1 In the first test suggested by Michele the hand of the affected side is placed on the opposite shoulder with the arm at a horizontal plane The examiner stands behind the patient on the normal side and with one hand draws the elbow across the chest thereby exaggerating the adduction of the patient's arm The thumb of the examiner's opposite hand is used to exert pressure in the region of the superior medial angle of the scapula whereupon the patient will complain of extreme tenderness, and radiation of pain into the affected areas

2 The second test is carried out with the examiner standing behind the patient holding the wrist of the affected side so that the arm is extended and *internally rotated* Pressure is exerted over the superior medial angle of the scapula with the examiner's free thumb With this maneuver the scapula is angulated *away from the chest wall* using the upper border as a fulcrum The additional pressure of the examining thumb will elicit pain and the *radiation* may be produced or exaggerated

3 *In the third test* the point of tenderness can be elicited by deep pressure of the examiner's thumb underneath the midportion of the descending fibers of the *trapezius* deep onto the posterior chest wall Reinforcement is produced by backward flexion and internal rotation of the arm

Sarcoma is rare Davis reported a case of primary giant cell sarcoma of the scapula, treated by total removal of the bone He first exposed the coracoid process and cut the pectoralis minor, coracobrachialis and the short head of the biceps He then doubly ligated the subscapular artery and vein, cut between them and packed the axillary wound with gauze Then he made an incision along the vertebral border of the scapula and another along the spine of the scapula Nancrede recommended inter costohumeral amputation in preference to total removal of the scapula

Fractures of the scapula are caused by falls or the blows of heavy objects According to Findlay they usually occur in the hazardous occupations of the male laborer in his early forties, by a severe form of trauma, which also results in many associated injuries There is pain and limitation of movements in the shoulder and tenderness over the scapula The first roentgenogram of the injured region may fail to reveal a fracture as it is usually taken for ribs also but not infrequently subsequent films centered on the scapula will show a fracture

The spinous supraspinous and infraspinous areas of the body, the supra glenoid and the infraglenoid areas, the coracoid and the acromion processes may be fractured The high morbidity and the mortality are due to associated injuries In one case I removed the lower half of the scapula with an excellent result

THE SCAPULOTHORACIC AREA

Scapulothoracic Bursitis —Although the scapulothoracic juncture is not a joint movement between the scapula and the thoracic wall is greater than that of many joints in the body A bursa may develop and cause considerable pain, annoyance by crepitus and limitation of shoulder move ment Scapular crepitus grating or snapping occurs when the shoulder girdle is moved, causing friction between the scapula and the chest wall It may produce a loud snap or a soft or fine grating I have seen it occur bilaterally in young soldiers in the signal corps who indulged in persistent overactivity of swinging the arms while "wig-wagging" The crepitus is usually audible and palpable

Subscapular bursitis is found in the round shoulder type The scapulæ have grown too curved during childhood from the forward position of the shoulders and are often bent enough so that the superior angle is hooked forward This rubs back and forth over the chest wall producing thickening of the bursa Under occupational strain infection or toxic irritation the bursa becomes inflamed and is made worse by all movements of the shoulder The examiner stands behind the patient and places his hands over the shoulders with thumbs pressed over the upper inner angles of the scapulæ When the patient shrugs his shoulders up and down and forward and backward, crepitation is felt and pressure at this point will often elicit tenderness and pain

Milch and Burman have classified this condition etiologically in seven types (1) the tubercle of Luschka (2) abnormal curvature of the superior angle of the scapula (3) exostosis of the ribs or scapula (4) tumors of the ribs or scapula, (5) fractures of the scapula or ribs (6) angulation or buckling

entirely negative—the basic lesion is visualized with difficulty or not at all. The diagnosis is often made by exclusion.

The differential diagnosis includes: The facet syndrome, fibrositis, foramen disorders, herpes (present or imminent) and pleurisy.

Acute Painful Interscapular Stiff Back.—Few minor conditions that affect human beings are more distressing than acute pain between the shoulder blades. The most frequent causes are trauma (a strain, a sprain or a draft of cold air) and infection. The symptoms are intense pain, stiffness and tenderness. Persons subject to these attacks learn how to guard against them. The best therapeutic measures are the application of heat, deep massage and adhesive strapping or a tight vest.

I predict that more and more cases of recurrent interscapular backache will be treated by surgery. The three chief procedures will be soft tissue stripping operations, disk explorations and spinal fusions.

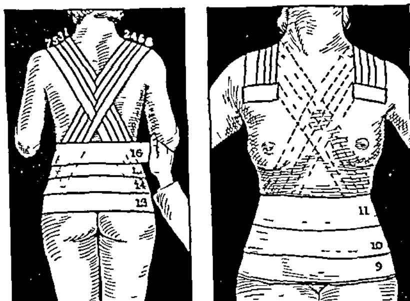


Fig. 182.—Adhesive strapping for interscapular pain. (Disregard Nos. 9 to 16.) (Courtesy of Johnson & Johnson.)

THE MAMMILLARY TUBERCLE OF THE LAST THORACIC VERTEBRA

The mammillary process of the twelfth thoracic vertebra may be large and prominent. On the articulated spine it conceals the joint between the superior articular process of the twelfth and the inferior articular process of the eleventh thoracic vertebrae. The size and relation of the process localizes the twelfth thoracic vertebra in surgery of the spine. In spine fusion operations involving the eleventh and twelfth thoracic vertebrae a resection of the process is necessary for proper exposure of the joint between these two vertebrae.

THORACOLUMBAR FRACTURE DISLOCATIONS WITH PARALYSIS

The key areas is the thoracic 12 and lumbar 1. The paralysis is usually from the waist down. Beevor's sign may be positive or negative.

In most instances, there are no significant x-ray findings In some cases, however, calcification in the region of the supraspinatus tendon may be noted It is the opinion of Michele s group that, in spite of x-ray evidence of cervical arthritis or calcification in the subdeltoid bursa, one should rule out the presence of a scapulocostal syndrome

Treatment of the scapulocostal syndrome may be divided into two parts

Preventative —Postural exercises to correct the rounded shoulders and slight thoracic kyphosis, are essential The patient should avoid the use of large or multiple pillows at night The use of a fracture board to prevent exacerbation by a sagging mattress is indicated

Definitive —Procaine, 5 to 10 cc of a 1 per cent solution injected into the subscapular tissues, produces dramatic relief from the local tenderness Postural exercises are prescribed later

A figure-of eight or a posture correcting shoulder harness may produce relief in some cases The ethyl chloride spray should be tried

Infraspinatus Syndrome —Pain in the shoulder girdle and lower arm is often due to reflex radiation which has its origin in the infraspinatus fossæ Judovich and Bates find the trigger point about 3 5 cm (1⅗ inches) below the midspine of the scapula Pressure and rolling with the finger reproduces and intensifies the painful radiation to the shoulder and arm This point should not be labeled as a fibrositic deposit, since it is constant in its location This may be the branch of the suprascapular nerve which supplies the infraspinatus muscle—a Valleix point

INTERSCAPULAR BACKACHE

Interscapular back pain is an example of a minor condition that causes major discomforts It is a disorder that has been neglected by the doctor but not by the patient It is poorly understood chiefly because it is not considered to be activated by disk derangements It is rarely considered surgical

It may be due to exposure to cold and dampness Posture is an important factor Many cases are due to unrecognized disk lesions One should always think of a disk derangement first but diagnose it last

The causes include

Trauma—sprain—strain	Synovitis
Ligament injury	Fascitis
Diseases	Epiphysitis
Fibrositis	Disk lesions
Facet derangement	Pleurisy
Foramen encroachment	Pneumonia
Arthritis	Tumors

The history is usually intermittent pain and stiffness The pain is aggravating Physical findings include limitation of movements tender trigger-points and often small areas of spastic muscles X-rays are usually

sclerosis The roentgenogram does not always show signs of disk degeneration The myelogram supplies additional information The *diagnosis* is usually made only at operation With hard, calcified disk protrusions, *decompression of the cord* should be carried out Attempts at removal, may result in trauma to the spinal cord

Keegan describes nerve root pain as a very common symptom, related to pathology of the spine or within the spinal canal When this pathology is in the lower thoracic spine, there is reference of pain obliquely around the trunk to the abdominal wall With this nerve root pain, there is variable abdominal hyperesthesia, muscle spasm and tenderness to pressure, simulating an inflammatory process in an underlying abdominal viscus If the nerve root involvement is inflammatory, as in herpes zoster, fever and leucocytosis may be present

There are some characteristic features of nerve root pain The most important is the band-like radiating course around the trunk with localization of pain and tenderness over a limited portion of the spine With this distribution, there usually is some demonstrable segmental sensory disturbance, either hyperalgesia or hypalgesia The presence of hypalgesia or faint sensory loss in the recognized distribution of a nerve root is definite evidence of loss of function of that nerve root The presence of a segmental band of hyperalgesia is not so certain in its indication of direct nerve root involvement for there can be segmental cutaneous reference of pain and hyperalgesia from an involved abdominal viscus The lower angle of the scapula, eighth thoracic nerve root pain from gall bladder involvement and the supraclavicular fourth cervical nerve root pain associated with irritation of the center of the diaphragm, are familiar examples

It is only if examination of the neck, scapula and upper limb reveals no abnormality that the existence of a thoracic lesion is suggested Not only must thoracic extension (prone), flexion (supine), side-flexion (side-lying) and rotation (sitting) be tested against resistance, but resisted scapular and arm movements must be carried out as well

The pattern that emerges when a thoracic spinal lesion is present is as follows Pain, perhaps also limitation, on some thoracic active movements, more pain when these movements are carried out passively no pain when the same movements are attempted against so great a resistance that the joints do not move A combination of articular with dural signs is common but either may be present alone

Love and Kiefer report that from 1922 through 1948 the diagnosis of a protruded intervertebral thoracic disk has been verified at operation at the Mayo Clinic in 17 cases The relative incidence of cases of protruded disks in the thoracic region among all cases of protruded intervertebral disks (lumbar and cervical as well) was estimated for a ten-year period

During this *period* about 5500 operations were carried out for protruded intervertebral disks Investigation disclosed that in 12 of their 17 cases the operation had been performed during these years This gives a relative incidence of about 2 to 3 cases of protruded disks in the thoracic region per 1000 disk cases

One of the few contributions to our knowledge of thoracic disks was made by Cyriax

Mason, Cozen and Adelstein reported a case in which severe flexion deformity of the neck was relieved by osteotomy of the cephalic portion of the thoracic spine

THORACIC DISK DERANGEMENTS

Protrusions of Thoracic Intervertebral Disks—Thoracic disk derangements have been given little space in medical discussions and in the literature They are therefore very often overlooked They appear to be so uncommon that they are prone to be excluded from the diagnostic scoreboard Thoracic intervertebral disks protrude much less frequently than those in the lumbar and cervical regions

Protrusions of intervertebral disks occur in the thoracic region in about the ratio of 3 to 1000 in the lumbar and cervical regions combined

When knowledge of this lesion occurring in the thoracic region is extended and it is recognized early and treated properly the results will improve Thoracic disk lesions are by no means uncommon and should always be considered in the differential diagnosis of obscure pain involving the trunk

Four cases of thoracic disk protrusion with compression of the spinal cord were described by Muller All patients were middle-aged or elderly men In no case was there a history of trauma Three patients had spinal root pain In two cases the clinical picture corresponded respectively to a severe and an incomplete transverse lesion in both cases with a superficial sensory disturbance of the dissociated type In one case the course was remittent At a certain stage a Brown-Sequard syndrome developed which later subsided In one case there was only a spastic paresis in one leg Roentgenograms revealed in two cases calcification within the damaged disk In all cases myelography was carried out with positive information

A study of the records in Love and Kiefer s 17 cases of protruded intervertebral disk in the thoracic region of the spinal column failed to disclose any etiologic factor in the majority of cases A history of trauma was obtained in only 5 cases The duration of symptoms in these 17 cases varied from rapid progression to a paraplegic state within three weeks of the time of appearance to twenty four years of intermittent attacks of lumbago The symptoms and signs varied widely depending on the size of the protrusion its location in regard to the spinal column and the local situation in regard to the spinal cord Tumor or degenerative or inflammatory disease of the spinal cord was considered in the diagnosis

The diagnosis of a space occupying lesion in the majority of cases was established on myelographic examination of the spinal canal

Signs and Symptoms and Diagnosis Radicular paresis and atrophy of the intercostal and abdominal muscles are usually not observed Even the segmental sensory changes frequently escape notice

The medially situated thoracic disk protrusions usually give the clinical picture of a transverse spinal cord lesion In some cases there is dissociated impairment of the superficial sensibility which might suggest an intramedullary process A remittent course may lead to confusion with multiple

spinal canal than to the other. This can be determined by the neurologic findings and at operation by palpating the lesion extradurally. Laminectomy should be extended farther laterally on the side where the protrusion is more prominent so that the lesion may be approached extradurally with the least possible rotation and elevation of the spinal cord. Usually it is advisable to divide the nerve root opposite the site of protrusion but not on the side from which the protrusion is to be removed. If the protruded portion of the disk is large or is centrally located, it is advisable to open the dura and divide some teeth of the dentate ligament, in order to permit the cord more freedom of movement and to lessen the traction on the cord while removing the fibrocartilaginous protrusion.

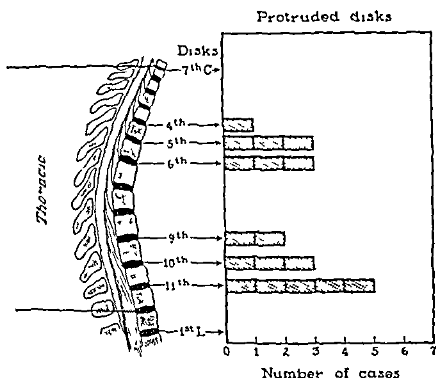


Fig. 183.—Sagittal section of the thoracic portion of the spinal column showing site of the lesion in 17 cases of protruded intervertebral disk in which the diagnosis was verified at operation. (Love and Kiefer.)

Treatment of Love and Kiefer's 17 cases consisted of laminectomy with removal of the protruded fibrocartilage in 15 cases and decompression of the cord without removal of the protruded portion of the disk in 2 cases. The results of surgical treatment were brilliant in those cases in which root pain or cord compression or both were present without gross neurologic deficit. The patients who had marked compression of the cord prior to operation usually had residual symptoms or signs indicative of irreversible damage to the cord. Thus it is evident that in order to obtain better results in these cases the condition must be suspected, recognized and treated before irreparable damage to the spinal cord has occurred.

Since the cervical and lumbar symptoms once ascribed to fibrositis are now becoming more generally regarded as having an articular origin the question naturally arises are the thoracic symptoms once ascribed to fibrositis also caused by disk-lesions? Cyriax has come to the conclusion that they are The marked signs that eventually serve to clarify the diagnosis in cervicolumbar protrusions seldom appear at the thorax however long a patient is kept under observation, hence this theory is correspondingly difficult to prove Moreover operation which has established the pathology of disk-lesions in the lumbar and cervical regions so firmly, is very seldom performed at the thoracic spinal levels

At the cervical and lumbar joints an alteration exists that leads to simplicity in diagnosis A minor degree of protrusion interferes with the joint not yet with the nerve-root hence local pain and articular signs are most obvious when neurological signs are lacking Alternatively when the protrusion has passed postero laterally and interferes little with joint movement it then exerts its maximum pressure on the nerve root, hence root pain and clear neurological signs supervene as the articular symptoms and signs fade By contrast disk lesions occurring at the thoracic joints by no means show this characteristic sequence There is an extraordinary variation in the mode of onset moreover the articular signs are seldom obvious and neurological signs conspicuous only by their absence No wonder therefore asks Cyriax do clinicians properly hesitate to implicate a thoracic joint as the source of what used to be called 'fibrositis' 'pleurodynia' or intercostal neuritis

Pressure on the dura at any thoracic level does not as it does at the lowest lumbar levels give rise to limitation of straight-leg raising

Manipulation is often a quick effective treatment but unhappily in a large proportion of cases the reduction is not permanent Physicians render a disservice to their profession and present a gratuitous advertisement to lay manipulators every time a patient with a cervical thoracic or lumbar disk lesion capable of manipulative reduction is left to wander on his own initiative into unqualified hands

Some surgeons are loath to undertake operations for protrusions of disks in this region because of the danger of causing irreparable damage to the spinal cord

Surgery for thoracic disks must be very meticulous in technical skill The dangers are injury to spinal nerves and the spinal cord Injuries to pleura or lung may be serious The anesthetist must be prepared for positive pressure measures

Since protrusions of thoracic intervertebral disks often compress the spinal nerves and since the thoracic portion of the spinal cord occupies much more of the spinal canal in the thoracic region proportionately than the cauda equina does in the lumbar region and since the spinal cord cannot be handled with the same relative impunity that a nerve root can Love and Kiefer consider adequate exposure essential Hemilaminectomy gives sufficient exposure in cases of involvement of a single nerve root with the protruded disk lying far laterally When the lesion lies in the midline and when there is motor or sensory impairment or both bilateral laminectomy is advisable Usually the lesion will extend more to one side of the

frequently in the spine. Carcinoma is the most frequent cause of sudden collapse of a vertebra, except osteoporosis.

Even though an injury has a bearing on the development or localization of a vertebral tumor, the odds are against the cause being the particular injury to which the lesion is ascribed by the patient. The important consideration is whether a tumor is malignant or benign.



FIG 184.—Complete destruction of 1st lumbar vertebra due to a malignant tumor

CLASSIFICATION OF BONE TUMORS

The Registry of Bone Sarcoma was founded by the American College of Surgeons under the leadership of Dr. E. A. Codman and his good work was carried on by D. B. Phemister. It has performed a noteworthy service. The classification adopted by the Registry contains eight divisions: (1) metastatic tumors of bone, (2) periosteal fibrosarcomas, (3) osteogenic tumors (benign and malignant), (4) inflammatory conditions, (5) benign

CHAPTER 29

TUMORS OF THE VERTEBRÆ

The vertebræ, being particularly rich in spongy bone, are sites of predilection of metastases. Schmorl has shown that the dense ring-like shadows on the upper and lower surfaces of the vertebra belong genetically to the intervertebral disk, and fuse secondarily with the vertebra. These shadows are less dense in persons under fifteen and in the aged.

The fact that the vertebra consists exclusively of spongy bone has a decisive bearing on the roentgenologic visualization of lesions occurring within them, for the reason that although both the spongy and the compact portions consist of calcium-containing bone tissue, there is an important difference between the structures of the two parts. The spongy bone forms a wide meshwork of very thin trabeculæ while the compact bone forms a thick layer of dense bone tissue. Consequently, the spongy bone produces a shadow of much less density than the compact bone. A defect which is visible in a compact bone may be quite invisible in a spongy bone. For this reason lesions in the vertebræ may go undetected.

A defect in vertebræ can be visualized roentgenologically because of two factors: (1) the defect is portrayed roentgenographically, that is, the rays traversing the defect are parallel to its longest axis; (2) the defect changes the contour of the vertebra (Borak).

Ferguson finds that in some spine lesions decalcification may not be recognizable because of the great thickness through which the spine is viewed. Many lesion not discernible clinically are quite obvious on post mortem examination of the vertebra.

While practically any type of tumor may occur in the vertebræ, the most common are: metastatic carcinoma, hemangioma, osteitis fibrosa cystica, myeloma, chondroma, osteoma and sarcoma. The diagnosis is based on the history and the roentgenograms. Diagnosis is chiefly by roentgen ray because biopsy material is not so readily available as in tumors of the long bones. Physical examination and laboratory tests may aid. A history of primary carcinoma in any organ, especially the uterus, breast or prostate is significant. A history of trauma has medico legal importance. Every person who has a malignant tumor operated on should have roentgenograms of all the vertebræ, ribs, pelvic bones and skull filed for future reference.

The subject of tumors of the vertebræ is divided into general considerations and special tumors. A deferred or mistaken diagnosis may result in great suffering. Roentgen evidence in the spine is the bulwark of diagnostic aid.

The most important tumors of the vertebræ are carcinomas, sarcomas, hemangiomas and chondromas. Most tumors of the vertebræ are metastatic carcinomas. Sarcomas, myelomas and hypernephromas occur less

Etiological Factors — The contributing factors in vertebral tumors are age, trauma, primary tumors in other organs and heredity.

A vertebra is one of the connective tissues of the body and its density and hardness result from adaptation to render it sufficiently resistant and strong to bear the body weight. If one removes the mineral content there remains a connective-tissue basis, from which the primary tumors of bone take their origin.

Pathological Changes — The gross pathological changes revealed by the roentgen ray usually determine the diagnosis, treatment and prognosis.

Geschickter and Copeland emphasized the relation between bone origin and development and tumor formation. From an embryological point of view, they divided the neoplasms of bone into two large groups: those arising in persistent preosseous and precartilaginous connective tissue, and those arising in connection with subsequent growth of cartilage. Approximately half of all primary neoplasms of bone are related to precartilaginous connective tissue, including osteochondromas, chondromas, chondromyxosarcomas and osteoblastic sarcomas.

Symptoms — The symptoms of vertebral tumors are pain, tenderness and limitation of movement. Pain may be entirely absent, or it may be boring, a dull rheumatic ache, or sharp and lancinating, depending upon the duration and special local situation. Bone pain is usually more marked at night and is only partially relieved by fixation. Tenderness to touch, sensitiveness to movement and immobility may be the first symptoms.

Pain Due to Secondary Carcinoma of Bone — Teddy emphasizes the fact that carcinoma may spread to bone at any time and that metastatic involvement of bone is not always a late process. At first, the pain may be mild and one that can be mistaken for something else, especially if the results of roentgenographic examination are indefinite or inconclusive. As time passes the pain becomes more severe and constant. It may become so severe that increasing doses of narcotics may be required for its control.

Roentgen-ray Observations — The roentgenologist is the key person in the diagnosis of vertebral tumors. Because of his large experience and daily contacts with numerous clinicians he is able to determine whether a lesion is inflammatory or neoplastic. If the latter he can usually determine whether it is benign or malignant and whether it is likely to respond to radiation therapy. Inflammation may closely simulate a tumor roentgenographically. In many cases the prognosis of the roentgen expert is valuable.

According to Borak, if one studies the relationship between the clinical and roentgenologic findings in bone metastases two groups can be distinguished. One group comprises metastases which give clinical symptoms but occult metastases are invisible roentgenologically. The other group of metastases may be roentgenologically visible without causing clinical symptoms.

Only in an advanced stage can a lesion in the vertebra become visible. On the other hand, even the smallest defect can be recognized roentgenologically if it causes a change in the contour of the vertebra. In other words, a defect seen because it is portrayed roentgenographically is a late roentgen finding; a defect seen because it changed the contours of the vertebra may be an early roentgen finding. Hence the practical rule: In searching for

giant cell tumors (6) angiomas (benign and malignant), (7) Ewing tumors and (8) myelomas

Campbell divided tumors of the bone according to their origin, as follows (1) osteogenic, derived from or composed of tissues or of cells whose function it is to produce bone such as osteochondroma, possibly giant cell tumor and osteogenic sarcoma, (2) non-osteogenic, derived from tissues residing in bone but not associated with osteogenesis, such as endothelial myeloma, myeloma and extraperiosteal sarcoma, (3) metastatic brought into the bone from primary tumors elsewhere in the body, through the blood stream or lymphatic vessels or, rarely, by direct invasion, as in carcinoma and hypernephroma

Geschickter and Copeland's classification of bone tumors is based on osteogenesis

I TUMORS RELATED TO OSTEOGENESIS

A *Tumors derived from pre-cartilaginous connective tissue*
1 Osteochondroma or benign exostosis
2 Chondroma or benign chondromyxoma
3 Primary chondromyxosarcoma
4 Secondary chondromyxosarcoma
5 Osteoblastic osteogenic sarcoma

B *Tumors related to subsequent cartilaginous growth*
1 Chondroblastic sarcoma
2 Osteolytic osteogenic sarcoma
3 Bone cyst and osteitis fibrosa
4 Benign giant cell tumor

II TUMORS OF NON-OSSEOUS ORIGIN

1 Primary lymphoma of bone (endothelial myeloma of Ewing)
2 Multiple myeloma
3 Metastatic carcinoma
4 Fibrosarcoma and neurogenic sarcoma

Primary bone tumors seldom arise in the vertebral column Osteogenic sarcoma Ewing's sarcoma and reticulum cell sarcoma are extremely uncommon according to Coley in this location Plasma cell myeloma having a marked predilection for red marrow areas of the skeleton affects the vertebræ in a high percentage of cases while metastatic cancer particularly of breast and prostatic origin likewise involves the vertebræ with great frequency

Giant cell tumor may give rise to serious cord compression Bloodgood in a series of 179 giant cell tumors found 5 cases in which the vertebra were involved Lewis reported 17 cases of vertebral giant cell tumor Bone cyst of the spine is rare Chordoma is confined almost exclusively to the spinal column

In forty years experience the most common vertebral neoplasms that I have encountered are

1 Metastatic carcinoma
2 Hemangioma
3 Multiple myeloma
4 Hypernephroma
5 Osteomas
6 Osteoid osteoma

cortex In addition to the marrow blood withdrawn, small elements "units" of bone marrow can be withdrawn intact The whole is placed in a paraffin-lined heparinized glass tube The use of these small "units" permits fixed tissue technics to be employed on the same bone marrow from which volumetric studies and smears are made

The pathologic cells seen in smears of the bone marrow in multiple myeloma vary from the very anaplastic and immature cell, to the well-differentiated and characteristic plasma cell

Biopsy —Diagnosis and prognosis are coming to rest more and more on the properly trained clinical cytologist His function is one of prognosis, not terminology and his main duty is to inform the surgeon whether the lesion is inflammatory hemorrhagic or neoplastic If it is neoplastic he should also determine whether it is benign or malignant

If any doubt persists when radical measures are anticipated, an "aspiration biopsy should be done There are divergent opinions concerning the dangers of biopsy It should be considered a major procedure since strict asepsis is of paramount importance Infection is one of the most serious complications of a malignant tumor Not only does it intensify pain, aggravate the cachexia of the patient and possibly even lead to death from septicemia but it has also an irritating effect on the tumor itself and may favor metastases by causing hyperemia and dilatation of the lymph spaces Infection interferes with subsequent irradiation Two further objections offered to biopsy are the danger of stimulation of growth and dissemination of malignant cells Penicillin should be given for three days after biopsy

The roentgenogram shows bone destruction and bone production, and variations in these two processes yield certain data on which a differential diagnosis can be based Age and sex are important One does not expect to find carcinoma in the young If a malignant tumor is found in the bone of a child, it is usually sarcomatous Similarly, a malignant growth in the pelvis of a woman over fifty is probably a carcinomatous metastasis from the breast, while in a man of the same age the growth is likely to be a metastasis from the prostate

Differential Diagnosis —Coley says that one must first decide whether a lesion of the spine is a tumor or some non-neoplastic condition Among the latter are tuberculosis hyperparathyroidism, Hand-Schuller-Christian's disease in children, and osteoporosis in elderly subjects (especially post-menopausal osteoporosis)

If the lesion is considered to be a tumor it must be decided whether it is benign or malignant Of the benign tumors, hemangioma and giant cell tumor are likely possibilities and they may be readily distinguished by the roentgenographic appearance

If it seems probable that the tumor is malignant the decision as to its being primary or metastatic must be made Complete skeletal films should be made If there are other areas found, primary bone sarcoma is eliminated and sternal marrow puncture plasma protein determination and Bence-Jones test of the urine may establish whether it is myeloma or metastatic carcinoma If the diagnosis is still in doubt a biopsy by means of aspiration is less hazardous than is an open surgical biopsy for tumors of the vertebral bodies and may yield satisfactory material for histologic interpretation

an early sign of a spinal metastasis one should not expect to find decalcification or deformity Let him first of all study the contours of the vertebræ If there is evidence of the slightest change, such, for instance, as a blurred or angulated contour, diagnosis of a spinal metastasis must be considered

It is a wise procedure in cancer of the prostate to take films of the vertebræ before an operation is performed, because metastases may be present in the absence of clinical symptoms

The changes produced by a neoplasm must be divided into primary and secondary Baetjer stated that the six points which follow should always be carefully noted on the film (1) the place where the lesion starts, (2) the character of the destructive process, (3) the path of extension—whether spreading in all directions or following the path of least resistance (4) the character and situation of the new bone produced (5) the condition of the cortex—whether intact, destroyed as a whole or pierced by sinuses, expanded or unexpanded and (6) the type of periosteal reaction—whether parallel or perpendicular to the long axis of the bone

Diagnosis — All tumors of the vertebræ must be either primary or metastatic There is no primary epithelial tissue in bone and if carcinoma is present, it must have entered by way of the vessels through the nutrient canal and have lodged in the medullary canal and grown there Since sarcoma is of connective-tissue origin it may be either primary in the medullary canal or metastatic

The systemic reaction to vertebral tumors may be mild or severe and may manifest itself in variations in temperature, hemoglobin and blood cells Endothelioma of bone may be accompanied by fever Under the mistaken diagnosis of acute osteomyelitis, this tumor has been operated on more than any other

Metastases prove the malignant character of a tumor Lung metastases are most common and serious

According to R H Jaffe osteogenic sarcomas may be bone building (osteoblastic or sclerosing) or bone destroying (osteolytic) Both types occur during the period of most active bone growth during or soon after puberty

Gouly and Gillespie devised a trephine to secure marrow specimens for histological study and smears for routine staining The sternum is an ideal source of supply both because of ease of access and because of its persistent functional activity throughout life The ribs show equal activity

Limarzi and Bedinger designed a modification of the Klima-Rosegger needle which facilitates bone marrow aspiration Marrow is most commonly aspirated from the sternum The needle is inserted in the third interspace in the midline in an adult The second interspace or the manubrium is used for small children For aspiration from the iliac crest a site two centimeters below the superior crest joining a line drawn 4 centimeters posteriorly from the anterior superior iliac spine may be chosen The technics of sternal aspiration have been modifications of Arinkin The method employed by Schleicher follows

One to 2 cc of the marrow material is withdrawn with a dry sterile syringe from the gladiolus at the level of the second interspace after inserting the tip of a guarded needle *and stylet 1 to 2 mm beneath* the inner table of the

osteogenic tumor excellent after radical excision, (3) osteogenic sarcoma, bad no matter what its treatment (4) benign giant cell tumor good under almost any treatment except poor surgical measures, (5) Ewing's tumor, good after immediate reduction under roentgen radiation but eventually bad, (6) myeloma certainly and slowly bad but its progress probably can be retarded by irradiation

The general practitioner must realize the importance of immediate roentgen and laboratory examination

Treatment — The various methods of treatment of vertebral tumors include (1) roentgen therapy, (2) radium therapy, (3) curettage, (4) resection and bone graft (5) braces, (6) casts, (7) transfusion, (8) calcium, (9) vitamin D, (10) HCl (11) frames, (12) traction, (13) opiates, (14) chordotomy (15) rhizotomy

BENIGN TUMORS OF THE VERTEBRÆ

The benign neoplasms which most commonly affect the vertebræ are the giant cell tumor and the hemangioma Each has a more or less characteristic appearance in roentgenograms They may cause pressure on the spinal cord or cauda equina Diagnosis is generally made from the roentgenogram

Osteomas may be single or multiple with a long history and slow growth There is often no pain unless the mass causes pressure on other tissues The structure of the tumor resembles that of normal bone Osteoma may occur in any portion of a vertebra It is seen in persons of all ages It may cause serious symptoms by compression and mechanical impingement

Osteitis fibrosa cystica occurs both as an isolated lesion in a vertebra and as part of a generalized condition

Chondromas of vertebræ affect either the spheno-occipital or the sacrococcygeal region of the spine of an adult and produce a bone-destructive lesion which increases gradually over months or years

Treatment —Owing to the great difficulty of a complete surgical removal of a tumor of the vertebræ roentgen therapy has been more widely employed than surgery

Roentgen therapy offers but little for osteogenic sarcoma or chondrosarcoma Coley finds it may afford palliation in plasma cell myeloma and it may produce excellent results in hemangioma or giant cell tumor There is no other practical method of local treatment of metastases to the spine except hormone therapy or castration for prostatic or mammary cancer Roentgen therapy should be given a fair trial in every case of spinal metastasis where the patient's general health permits An exception should be made in the highly specialized tumor known as chordoma which is highly radio-resistant Benign tumors which are confined to the transverse and spinous processes may sometimes be successfully treated by surgical means These include the cysts and giant cell tumors

Some of the conservative measures of treatment include a split mattress a special bed traction Bradford Herzmark or Stryker frame a plaster-of-Paris cast or shells a brace calcium gluconate intravenously daily dicalcium phosphate by mouth dilute hydrochloric acid by mouth, roentgen or

Bone Production in Bone Tumors — According to Baetjer the only two malignant bone producers are periosteal sarcoma and osteosarcoma. The benign bone producers are osteoma and ossifying hematoma. In an osteoma bone is laid down from a central point, in cauliflower like arrangement with a definite border.

One should suspect malignant change when severe pain is not relieved by fixation, if there is rapid invasion of the surrounding tissues and early involvement of the spinal cord with resulting paraplegia.

DIAGNOSTIC RULES FOR BONE TUMORS IN GENERAL

I have collected and formulated the following guides

The differential diagnosis of the kind of tumor is unimportant compared with the question "Is it malignant?"

Beware of making a diagnosis because the tumor looks like something you saw before.

Base the diagnosis on the principles of bone reactions to irritant factors.

Malignant tumors rarely invade or cross a joint.

The more scirrhous the primary tumor the more sclerotic the secondary unless it is very malignant. (Phemister)

The longer the history and the less the pain the more likely is an osteogenic tumor to be benign. (Codman.)

Central tumors of bone which are not metastases or multiple myelomas are seldom malignant.

Have Wassermann and Kahn tests in every case.

A splint should be applied in every case of tumor of a long bone, especially the femur or humerus to prevent fracture and minimize the danger of metastases to the lungs and vertebræ.

Every bone tumor in a woman who has had a breast removed, is potentially malignant.

Do not amputate an extremity without roentgenograms of the chest, ribs and vertebræ.

Do not amputate in the presence of metastases to the lungs or vertebræ except in the presence of extreme pain uncontrollable by opiate medication, recumbency, traction and radiation therapy.

Osteolytic forms offer a better prognosis after treatment with radiation than do the sclerosing forms.

Prognosis —The prognosis depends on the type of tumor, its age, its proximity to the shoulder or hip, the presence or absence of metastases especially in the lungs or vertebræ, the age of the patient and the treatment instituted.

The prognosis for each class of bone tumors is fairly definite.

Ewing's tumor probably has a more favorable prognosis following treatment by irradiation than does any other form of malignant tumor of the bone, but it is highly malignant and almost universally fatal. For myeloma, which is usually malignant, the prognosis is unfavorable.

Codman concluded that a bone tumor which is not inflammatory or metastatic may be considered as one of six varieties: (1) periosteal fibrosarcoma, for which the prognosis is fair after complete excision; (2) benign

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Codman concluded that a bone tumor which is not inflammatory or metastatic may be considered as one of six varieties: (1) periosteal fibrosarcoma, for which the prognosis is fair after complete excision; (2) benign

to its probable radiosensitivity. The response of a tumor to radiation is the most accurate and certain clue to its radiosensitivity. The tumor bed is important.

Several fundamental principles determine the success or failure of radiotherapy: (1) the extent of the lesion, (2) its anatomical structure, (3) its accessibility to radiation, (4) its radiosensitivity, (5) the technic employed.

The rays act not only on the cells of the neoplasm but on the cells of the normal tissues. According to Maximow, the fibrocyte, which is important in the process of healing, is particularly radiosensitive among the cells of granulating tissue.

The objects of preliminary irradiation are: (1) to test the radiosensitivity of the tumor, (2) to minimize the chance of metastasis, (3) to devitalize tumor tissue, and (4) to reduce the danger of recurrence.

Radium vs Roentgen Ray.—It is generally agreed that radium can accomplish everything the roentgen ray can, but *it is thought by some that it* takes longer and may affect normal bone. Burrows, Jorstad and Ernest believe that one of the actions of roentgen rays on the tissues is to remove their normal lipoid content, and that one of the chief actions in destroying carcinoma cells may be the removal of these lipoids, not only from the tumor tissues, but also from the normal tissues immediately adjacent to them. These lipoids are *necessary for the growth of the cancer cells*.

Operative treatment is justified under unusual circumstances, the method of choice being either fusion or a bone graft, chiefly to relieve pain, followed by irradiation, hormones, etc.

Hypermineralization.—For hypermineralization in carcinoma of bones, Brunschwig recommended the intravenous injection of 10 cc. of a 10 per cent solution of calcium gluconate three times a day and oral administration of 60 grains of calcium gluconate three times a day. The patient remains in bed one hour after each intravenous injection. That author used as much calcium for as long a period as the patient could tolerate it. I have obtained striking relief of symptoms in several cases of combined hypermineralization and irradiation.

The Effect of Testosterone on Patients With Bone Metastases.—Lazlo and his associates studied the action of testosterone under controlled conditions. They performed metabolic experiments in six patients with breast cancer with osteolytic metastases. Control studies were also performed in patients with extensive osteolytic malignancy. Diethylstilbestrol and later testosterone, were administered to a patient with multiple myeloma. A premenopausal breast cancer patient received *x*-ray castration. Testosterone induced accelerated osteolysis and hypercalcemia in three patients with breast cancer.

Diethylstilbestrol improved the mineral balance of the patient with multiple myeloma. Testosterone induced nitrogen retention with slight improvement of the mineral balance. X-ray castration of a patient with breast cancer temporarily improved the mineral balance.

Effect of Bilateral Adrenalectomy on Certain Human Tumors.—Huggins and Bergenstal found that the activity of certain neoplasms is dependent upon function of the adrenal glands and these tumors regress somewhat after adrenalectomy with maintenance of the host on cortisone acetate.

radium radiation, transfusions, and treatment of anemia, if present A semi rigid mattress is helpful

Auxiliary treatment includes recumbency, splinting to assist in relieving pain and to minimize the danger of fracture, head and pelvic traction opiates by mouth by rectum intravenously or intraspinally and operations on nerves to eliminate pain These include nerve blocking, resection, rhizotomy and chordotomy

Always splint the extremity that harbors a bone tumor to prevent a pathological fracture and minimize the danger of metastases

Bloodgood s rules of procedure for bone lesions, given in Geschickter and Copeland s book, follow

Irradiation can check the growth and permanently cure some tumors

A complete physical examination should be performed

Roentgenograms of the chest should be made in all cases of bone lesions One should always have roentgenograms of the pelvis, spine and chest and a lateral view of the skull in order to search for multiple lesions of the skeleton Repeated roentgenograms should be made

Blood Wassermann and Kahn tests should be made in every case When the lesion is in the spine there should be Wassermann and Kahn tests of the spinal fluid Complete blood counts should be made

Urine examination should include a test for Bence-Jones bodies in all cases of lesions of a bone

One should have blood chemical determinations

Body temperature should be recorded

A basal metabolic test should be made

Irradiation—Irradiation includes roentgen and radium therapy They are discussed appropriately under specific types of tumors

The pain of early metastatic lesions in the vertebræ, for example, those following carcinoma of the breast, can often be abolished by roentgen treatment The more nearly embryonic the cell the more susceptible it is to radiation whereas the more adult differentiated or specialized the cell, the greater is its resistance Tumors derived from structures highly susceptible to roentgen and radium rays are themselves very sensitive to them Tumors vary in radiosensitiveness, not only according to the cellular prototypes from which they are derived but according to the tissue in which they originate

Herendeen found no bone tumor with a more immediate and active response to irradiation than endothelial myeloma or Ewing s tumor especially in children or young adults

Tumors in adolescents are usually more radiosensitive than those in adults

After one has studied the roentgenograms of a bone lesion and completed the study of the case one should be able to classify the tumors into one of three groups—malignant borderline and benign

When the diagnosis is doubtful the patient should be put to rest the involved area irradiated and the roentgenograms submitted to more experienced diagnosticians The degree of radiosensitivity of a tumor may be estimated after a consideration of clinical histological and radiotherapeutic factors The anatomical site of a tumor constitutes the first clue as

portion of the body of the vertebra described by Hanson. However Makrycostas showed that usually the latent angiomatous nodule lies at the center of the body.

Barnard and Van Nuys found that 10 per cent of postmortem examinations reveal primary hemangioma of the vertebra.

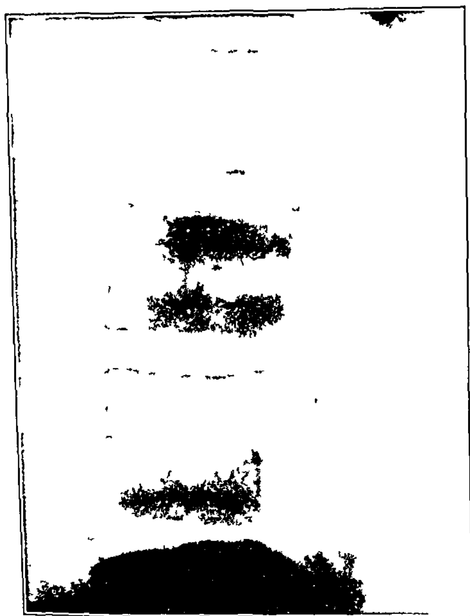


FIG. 185.—Hemangioma (or Paget's osteitis deformans) involving the 2d lumbar vertebra.

Roentgenograms are characteristic, revealing vertical striations or well-spaced radiating spicules of bone similar to zebra stripes in the vertebrae. The irregular absorption of the bony trabeculae and thickening of the remaining vertical trabeculae produce dense parallel vertical striations in the body of the vertebra, together with loss of the normal homogeneous bone structure. Pathological study shows numerous groups of cavernous vascular channels and absorption and deposition of bone, appearing at

They also found that adrenalectomy with maintenance of the patient on cortisone acetate can cause some regression of far advanced mammary and prostatic cancers

Hendrick and Burton employed a colloidal solution of metallic elemental arsenic to demonstrate changes in the pathological structure of bone tumors following a series of intravenous injections of the solution over varying periods They observed certain definite changes especially increased calcification and ossification together with apparent retardation and cessation of bone destruction by the tumor cells

Cysts of vertebræ are rare The diagnosis usually depends on the characteristic roentgen appearance

Bucy and Camp found benign giant cell tumor and osteochondroma the most common benign tumors of the spine A giant cell tumor usually *affects the spine of the young adult below the cervical region* tends to involve the neural arches and produces a trabeculated lesion outside the confines of the body of the vertebra The healing phase produces bone cysts which may also be complicated with Recklinghausen's disease associated with parathyroidism and demineralization of the entire spine. Osteochondroma may occur in any portion of the spine The neural arches are affected by an osseous growth with a clearly demarcated osseous shadow visible in the roentgenogram

The radiosensitivity of the benign giant cell tumor is so characteristic that it constitutes a valuable diagnostic sign

Hemangioma of Vertebræ —*Cavernous Hemangioma* —The first roentgenogram of a hemangioma of the bone was described in 1917 by Hitzrot In 1930 Bucy and Camp reviewed all the recorded cases and classified the radiological findings Women were affected more often than men in the proportion of 9 to 2 and the midthoracic region was the most common location

Neurological symptoms due to vertebral hemangiomas had been reported in 36 cases in the literature to which Scheel added 2 cases Compression of the medulla was most often caused by hemangiomatous masses in the epidural space which had broken through the vertebral body or arch In 7 cases the only symptom was pain in the back with radicular pain radiating to the abdomen and lower extremities Compression and pain appeared in both old and young Neurological symptoms as a rule begin with weakness in the lower extremities paresthesia and pain generally follow, so that walking is difficult A spastic paralysis may develop into a complete paralysis Paralysis of the bladder may occur Usually there is progression during the course of months or years The roentgenogram shows a characteristic coarse-meshed structure

In reporting the twelfth case of cavernous hemangioma of the vertebræ which produced symptoms Bailey and Bucy stated that in 16 other cases angiomas of the vertebræ were seen at autopsy but there had been no symptoms The 16 cases in which autopsy revealed 52 angiomas of the vertebræ none producing symptoms and most of them in elderly persons show that hemangiomatous nodules probably are latent in the bone until some undetermined factor stimulates their growth Permann postulated that a great many lesions arise from the various plexuses in the anterior

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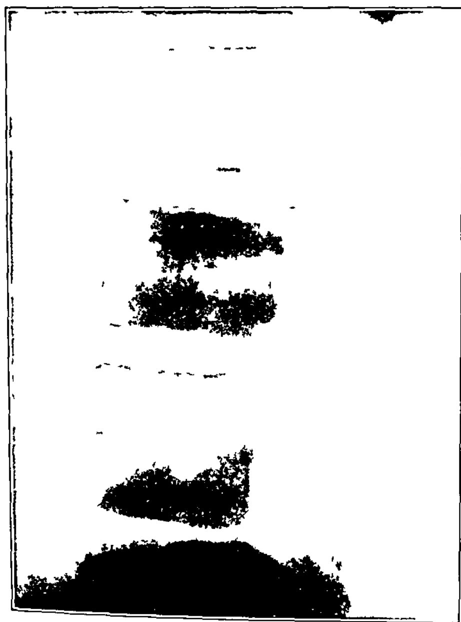


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Hemangioma of Vertebræ —*Cavernous Hemangioma* —The first roentgenogram of a hemangioma of the bone was described in 1917 by Hitzrot In 1930 Bucy and Camp reviewed all the recorded cases and classified the radiological findings Women were affected more often than men in the proportion of 9 to 2, and the midthoracic region was the most common location

Neurological symptoms due to vertebral hemangiomas had been reported in 36 cases in the literature to which Scheel added 2 cases Compression of the medulla was most often caused by hemangiomatous masses in the epidural space which had broken through the vertebral body or arch In 7 cases the only symptom was pain in the back with radicular pain radiating to the abdomen and lower extremities Compression and pain appeared in both old and young Neurological symptoms as a rule begin with weakness in the lower extremities paresthesia and pain generally follow, so that walking is difficult A spastic paralysis may develop into a complete paralysis Paralysis of the bladder may occur Usually there is progression during the course of months or years The roentgenogram shows a characteristic coarse-meshed structure

In reporting the twelfth case of cavernous hemangioma of the vertebræ which produced symptoms Bailey and Bucy stated that in 16 other cases angiomas *of the vertebræ were seen at autopsy but there* had been no symptoms The 16 cases in which autopsy revealed 52 angiomas of the vertebræ none producing symptoms and most of them in elderly persons show that hemangiomatous nodules probably are latent in the bone until some undetermined factor stimulates their growth Permann postulated that a great many lesions arise from the various plexuses in the anterior

Sarcoma of the vertebra may appear as an expansile tumor simulating a circumscribed abscess on antero posterior view, a lateral view may reveal the crushing of the vertebral bodies extensive destruction of the vertebræ accompanied by hyperplasia of bone

Osteogenic sarcoma of the vertebra including chondrosarcoma osteolytic sarcoma and sclerosing sarcoma may be secondary to multiple exostoses or to Paget s disease **Chondrosarcoma** tends to involve several vertebræ and produces characteristic calcified paravertebral shadows The roentgenogram in sclerosing sarcoma shows irregular formation of new bone in the soft parts Osteolytic sarcoma produces a rapidly extending region of osseous destruction, with infiltration of the soft parts

Jaffe described the **Ewing tumor** as a radiosensitive osteolytic tumor of the long bones composed of undifferentiated round cells arranged about blood vessels It has been found also in the ilium scapula, vertebral column and skull Some authors have traced its source to the endothelium of the lymph vessels Some investigators have denied that Ewing s tumor is a primary tumor related to bone stressing its metastatic, carcinomatous nature

The diffuse endothelioma of Ewing is exceptionally sensitive to radium and roentgen rays The only other radiosensitive tumor of bone is chondrosarcoma Osteogenic sarcoma on the other hand is resistant to irradiation

Besides the undifferentiated round cell sarcoma, there exists a reticular celled **lymphosarcoma** of the bone marrow, similar to the reticular-celled lymphosarcoma of the lymph adenoid tissue

Fifty-nine chordomas from the Mayo Clinic files were studied by Dahlin and MacCarty Thirty-two were found in the sacrococcygeal area fifteen at the base of the skull nine in the cervical area, two in the lumbar, and one in the thoracic region of the spinal column

The sacrococcygeal tumors presented chiefly as presacral pain-producing masses Considerable palliation has been afforded patients so afflicted by both surgical intervention and irradiation therapy alone or in combination Reasonable hope of permanent cure probably depends on radical surgical treatment

Chordomas affecting the spinal column may present from any side of the vertebræ or intervertebral disks, but they ordinarily cause neurological signs and symptoms by compression of the spinal cord or nerve roots Surgical excision produced prolonged remissions in two of the patients in this group The diagnosis of chordoma may be strongly suggested by the clinical and roentgenological findings, but verification depends on histological examination

MULTIPLE MYELOMAS

Multiple myeloma is a malignant disease characterized by bone pain, deformity and abnormal fragility of the bones, cachexia and Bence-Jones proteinuria The tumors are found most frequently in the spine ribs, skull the bones of the shoulder girdle pelvis sternum and upper ends of the humeri and femora Propp and associates note that these are the locations where active blood formation occurs in the adult

first to be honeycombed with dilated and tortuous capillaries The vertebral body does not collapse

Ramage reported that of 5 cases with compression symptoms, laminectomy was followed by death from post-operative shock in 3, while in 2 there was recovery following high voltage roentgen therapy Good results followed this treatment in 1 case in spite of the presence of spinal cord symptoms when treatment was started In another case the symptoms of pain and limited movement were relieved, but the bone showed no increased consolidation even after twelve months' treatment

A vertebral hemangioma with neurological symptoms calls for radiological treatment or laminectomy of the affected vertebræ and eventually also removal of the hemangiomatous tissue, which often extends epidurally

Ramage concluded that the occurrence of hemangioma of the spinal column must be connected with the venous plexus in the vertebral bodies The most prominent symptoms are those of compression Root pains do not occur

According to Lievre roentgen treatment should be given when the condition is mild with pain as the only symptom, operative treatment is indicated for paralysis of greater degree, in spite of the danger of hemorrhage Scheel recommended roentgen treatment, and especially powerful radium treatment, for severe compression

Vertebral Hemangioma With Compression of the Spinal Cord —Large series of autopsy material show that vertebral hemangioma occurs with a frequency of from 10 to 12 per cent However this growth seldom reaches a size that causes clinical signs The prognosis is poor if objective signs of compression of the spinal cord develop Lindquist reported a case of vertebral hemangioma with pronounced signs of compression of the spinal cord The patient was treated with irradiation He became free from neurological symptoms with the exception of a mild residual spasticity He recovered complete working capacity

MALIGNANT PRIMARY VERTEBRAL TUMORS

Ewing's hemangio-endothelioma (Ewing's sarcoma), osteogenic sarcoma and myeloma may occur as primary tumors of the vertebræ

Sarcoma

Malignant primary tumors of the vertebræ are not common Sarcomas of the vertebræ are rare Osteogenic sarcomas include chondrosarcoma and the osteolytic and sclerosing types Sarcomas of the tissues in the lumbosacral region usually appear as solid tumors and are often associated with peripheral root pains The roentgen appearance varies from erosion to sclerosis

Sarcoma usually produces a large tumor which develops rapidly In some cases there is bone erosion not confined to the vertebral body The osteoplastic type of sarcoma produces an increase in the density of the bones Roentgenograms reveal obliteration of the detailed structure of the bone suggesting gradual dissolution There is usually no evidence of bone formation

involve more than one bone Localized pain and tenderness are the most frequent clinical indications of bone lesions but tumors about the bone margins and neurological changes due to extension into the spinal canal from vertebral lesions are also observed Elevated serum phosphatase appears to be a promising index of bone extension from both lymphosarcoma and Hodgkin's disease The serum phosphatase is elevated in lesions with osteoplastic changes

The development of bone lesions in lymphosarcoma is often a terminal event Radiation therapy offers definite amelioration of symptoms in the osseous lesions of Hodgkin's disease and, in some cases, completely restores the invaded bone to its normal structure The doses given were moderate administered primarily for relief of symptoms rather than for restoration of bone Similar clinical improvement occurred in lymphosarcoma after radiation therapy

Lymphosarcoma and Hodgkin's disease are markedly affected by radiotherapy Endothelioma is relatively susceptible to radiotherapy, and the primary lesion generally responds well

A **chondromyxosarcoma** of the 6th cervical vertebra and intervertebral disk which produced compression paraplegia, was reported by Sharp and Jacob The spinal cord showed marked flattening from pressure outside the dura but no degeneration of any portion of the cord Multiple metastases were present in the lungs, which showed tumor masses of the same character as those in the vertebra and spinal canal

Sarcoma may arise from the vertebrae as well as from any other bone affected with osteitis deformans Compression of the spinal cord and nerves follows quickly Radiation offers little or nothing These tumors are highly malignant

The spinal cord may be compressed by the buckling of vertebra softened by osteitis deformans unassociated with malignant degeneration Hence laminectomy is often indicated particularly if there be any doubt regarding the diagnosis Relief of symptoms may follow If a sarcoma is discovered some temporary benefit may result from decompression and from division of the involved posterior nerve roots The prognosis in sarcoma of bone secondary to Paget's disease is very poor

METASTATIC MALIGNANT TUMORS OF THE VERTEBRÆ

Vertebræ may harbor metastases and an accompanying paralysis may be due to epidural or epispinal metastases

Rix and Geschickter reported 291 tumors in one series All of them affected bone or were demonstrable roentgenologically They included metastatic carcinomas primary tumors of the vertebræ, glial tumors and tumors of the neural sheath of the spinal cord tumors of generalized distribution (multiple myeloma), tumors of the sympathetic nervous system and tumors of teratological origin

Metastatic carcinoma was by far the most frequent neoplastic lesion in this series Classified according to site of origin it occurred as follows

Multiple myelomas frequently involve the spine. They are specific malignant tumors of the bone marrow, composed of plasma cells or their derivatives, characterized by multiple foci and are invariably fatal. Ghormley classified multiple myeloma as among the most common primary malignant tumors which involve the vertebræ.

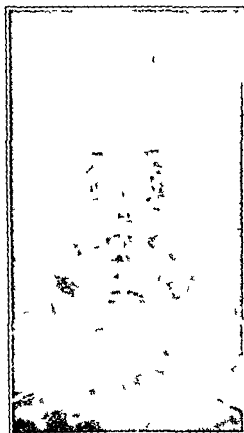


Fig. 186.—Multiple myeloma involving lumbar vertebræ, sacrum and ilii.

The characteristic roentgen appearance and the distribution of the lesions, together with the presence of Bence Jones protein in the urine or blood plasma, are highly indicative of the diagnosis, but biopsy furnishes the most reliable evidence. Morrissette and Watkins found that the blood smear is a valuable aid in the diagnosis; that the plasma cell type is predominant, and that the lesions are probably more like the leukemias than neoplasms.

The albumin globulin ratio is usually reversed. There is a negative nitrogen balance. The alkaline phosphatase is not normal.

A "Bone Survey" should include x-rays of the vertebræ, skull, ribs, pelvis.

Biopsy.—*A.* A sternal puncture usually supplies conclusive diagnostic evidence. The marrow smear reveals mature and immature plasma cells.

B. Biopsy of a lesion.

There is no curative treatment. However one should try: (1) Cortisone 250 to 300 mgm. daily divided into 4 doses, *i.e.* 75 mgm. q. 6 h. (2) Urethane 2 grams daily. (3) Limit the intake of sodium chloride. (4) Potassium chloride 3 grams daily.

Stilbamidine has been reported to be of variable value. Magnesium carbonate, 4 to 6 gms. daily or strontium carbonate 1 gm. three times daily may be helpful.

HODGKIN'S DISEASE AND LYMPHOSARCOMA

When Hodgkin's disease affects the vertebræ, it produces symptoms that are similar to those of tuberculosis or arthritis. The symptoms are pain, tenderness and limitation of motion. The roentgenographic changes may be indistinguishable from those of arthritis.

Vieta, Friedell and Craver found that the lesions most frequently discovered are in the pelvis, vertebræ, ribs and femora, and in most cases

quently roentgen examination of the entire skeleton is often necessary. A careful search for a primary focus must be made, the most important sites being the breast, the prostate, the cervix of the uterus, the thyroid, the esophagus and the lung.

Vertebral carcinoma must be metastatic from a primary growth. This is usually in the breast, uterus, prostate, thyroid, gastro-intestinal tract, kidney or adrenal gland. There is usually a history of a previous lesion, with operation and removal of a primary tumor. The disease rarely occurs before the fortieth year. It is the most painful of all conditions of the spine. Tenderness and sensitiveness are extreme. Movement is limited and there is a change in the general appearance of the patient. While in tuberculosis the intervertebral disks are usually involved, in carcinoma they may remain intact for a long period. The "bed test" means that rest in bed will usually afford relief for tuberculosis, but not for carcinoma. The diagnostic roentgen features are absorption of calcium, destruction of bone and often collapse of several vertebrae. The roentgenogram indicates that carcinoma does not invade the soft tissues or cross a joint.

Bucy and Camp found that metastatic carcinoma, usually from the breast or the prostate, is the most common neoplastic condition of the vertebrae. Cancer of the breast may produce metastases, usually multiple and destructive, in any region of the spine. Metastases from carcinoma of the prostate may involve the sacrolumbar region and produce sclerosis of the bone. These multiple lesions in adults must be differentiated from multiple myeloma, which produces multiple circular defects with a tendency to pathological fracture and collapse. Involvement of the spine in Hodgkin's disease, lymphosarcoma and leukemia may simulate metastatic carcinoma.

Meyerding emphasized that severe persistent pain which is not relieved by rest and mild sedatives and is associated with demonstrable lesions of the spinal column should suggest a malignant lesion. Metastases are *often found* even when the patient's general physical *condition* appears good, and when a primary lesion has not been suspected. Careful roentgen examination of patients with definite primary carcinoma will often reveal metastases to bone when pain has been ascribed to arthritis or neuritis. The more scirrhous the primary tumor, the more likely is the secondary to ossify.

Ghormley finds metastatic tumors by far the most common neoplastic condition involving the vertebrae. Metastases from neoplasms of the prostate in men and of the breast in women are most frequent. Other metastatic neoplasms of the spine arise from hypernephroma and growths in the thyroid gland, lungs, and other organs. In cases of intractable backache metastasis of a neoplasm should always be considered.

METASTATIC LESIONS OF THE SPINAL COLUMN

Metastatic lesions of the spinal column develop much more rapidly than do benign lesions but otherwise they produce symptoms similar to those of intraspinal tumors. They occur at a later age than the average intraspinal tumor does, which should make the surgeon extremely careful during examination of the patient to determine, if possible, the presence of a primary lesion. Exploratory laminectomy is rarely indicated.

Site of Origin	Number of Cases
Prostate	86
Breast	60
Undetermined	14
Gastro-intestinal tract	5
Kidney	4
Thyroid	1
Lung	1
Nasopharynx	1
Total	172

Carcinoma of the breast is one of the most frequent primary lesions producing metastases to the vertebræ

The second largest group of vertebral tumors reported by Rix and Geschickter was composed of 58 primary tumors of the vertebral column, distributed as follows

Type of Tumor	Number of Cases
Benign	
Giant cell tumor	15
Osteochondroma	10
Bone cysts	7
Chondroma	3
Hemangioma	2
Malignant	
Osteogenic sarcoma	
Chondrosarcoma	8
Osteolytic sarcoma	4
Sclerosing sarcoma	4
Chondroma	[illegible]
	58

The sites of origin of metastatic carcinomas of the spine in Schlesinger's series were as follows

Site of Origin	Number of Cases	Site of Origin	Number of Cases
Mammary gland	10	Bladder	1
Esophagus	9	Ovary	1
Thyroid	9	Sigmoid flexure	1
Uterus	6	Rectum	1
Bronchus	[illegible]	Kidney	1
Stomach	4	Adrenals	1
Prostate	3	Larynx	1
Gall bladder	2	Pancreas	1
Sinus piriformis	2	Origin not given	1
Total			59

Metastatic carcinoma of the spine usually consists of multiple lesions A solitary lesion occurred in only 25 per cent of Rix and Geschickter's series of carcinomas of the breast which produced metastases to bone Conse-

a series of 291 tumors studied by Geschickter and Copeland every bone was affected or demonstrable roentgenologically. They included metastatic carcinoma, primary tumors of the spinal column, glial tumors and tumors of the neural sheath of the spinal cord, tumors of generalized distribution (such as multiple myeloma), tumors of the sympathetic nervous system and tumors of teratologic and notochordal origin.

METASTATIC CARCINOMA

Metastatic carcinoma was by far the most frequent neoplastic lesion of the vertebral column. Of 291 spinal tumors 172 (59.1 per cent) were metastatic carcinomas. Schlesinger and Frazier pointed out the marked frequency of metastatic lesions of the spine. In adults such lesions must be considered in the differential diagnosis of any tumor affecting the vertebral column. Schlesinger in 13,500 autopsies found 59 metastatic carcinomas of the spine. Behney has shown that of 55 carcinomas of the uterine cervix which metastasized, 5 involved the lower lumbar vertebra.

Carcinoma of the breast is the most frequent cause of metastases to the vertebra. In a series of 100 carcinomas of the breast metastasizing to bone, 60 of the tumors were found to be in the spine.

In one case an interval of fourteen years elapsed between the amputation of the breast and the appearance of metastasis in the spine.

Carcinoma of the prostate is more characteristic in its metastasis to bone. In 134 cases it involved the spine in 86 and showed a marked tendency to appear in the sacral and the lumbar vertebra. It produces a lesion which is predominantly osteosclerotic. One patient lived three and half years after the recognition of the metastasis. In prostatic carcinoma the acid phosphatase of the serum is increased.

Geschickter and Copeland in most cases of metastatic carcinoma of the spine most of the lesions are multiple. A solitary lesion occurred in only 25 per cent of cancers of the breast metastasizing to bone. Consequently roentgen examination of the entire skeleton is often necessary. A careful search for a primary focus must be made, the most important sites being the breast, the prostate, the cervix, the thyroid, the esophagus and the lung. A large number of carcinomas of undetermined origin are encountered. The tendency of metastatic carcinoma of the prostate to cause osteosclerosis is the only consistent roentgenographic feature.

Treatment.—Roentgen irradiation of the affected area, rest and sometimes operative relief of compression of the spinal cord are advised by Geschickter and Copeland. The affected part of the spine should be protected by immobilization or by hyperextension. Life is often greatly prolonged by roentgen therapy and pain may be controlled. Castration and estrogen therapy is beneficial in cases of prostatic carcinoma with skeletal involvement. Sterilization followed by testosterone therapy is beneficial in mammary carcinoma with osseous metastases.

Metastatic carcinoma in adults, usually from the breast or from the prostate, is the most common neoplastic condition of the vertebral column. Cancer of the breast may involve any region of the spine; the lesions are usually multiple and destructive. Carcinoma of the prostate involves the

SKELETAL METASTASES OF CARCINOMA

Abrams found that in males, osteoblastic lesions were usually prostatic but often arose from the stomach, pancreas, or bladder. Osteolytic implants were largely pulmonary. Among females, both osteolytic and osteoblastic tumors were derived from the breast.

Freid and Goldberg found osseous metastases in 75 per cent of patients with metastatic breast carcinoma. Garland and co-workers state that skeletal metastases occur in a high percentage of cases of advanced mammary cancer. Pain, immobilization, fractures, severe anemia and hypercalcemia may accompany skeletal involvement.

Lazlo and associates find that the correlation of clinical and metabolic data of patients with metastatic malignancy is helpful.

Metabolic evidence as well as clinical observation indicate that even advanced *metastatic malignancy may proceed in waves of exacerbations* and remissions. The mineral loss caused by osteolytic breast cancer metastases is characterized metabolically by high urinary excretion of calcium and phosphorus with negative mineral balances. This metabolic process is not specific for breast carcinoma but is characteristic of skeletal destruction.

The excessive and prolonged mineral loss in patients with osteolytic metastases may result in hypercalcemia. The sequence of events in such instances appears to be: excessive bone breakdown, mobilization of calcium and phosphorus, hypercalcemuria and hyperphosphaturia, hypercalcemia, and finally renal impairment.

In *contrast* to the mineral loss caused by *osteolytic* metastases is the calcium retention caused by *osteoblastic* metastases. In osteoblastic metastases there is a subnormal urinary calcium excretion.

TUMOR METASTASES TO THE LUMBAR SPINE

Street, Funk and Young reported an analysis of tumor metastasis to the lumbar spine in 52 consecutive cases of neoplasm which came to autopsy. The survey was undertaken to study the discrepancy between *x*-ray findings and gross findings. At autopsy the lumbar spine was removed, *x*-rayed and then sliced into quarter-inch sections. Multiple microscopic sections were taken from each specimen. The specimens selected were encased in butyl methacrylate in the manner described by J. M. Peck and D. R. Gray (Tech. Bull. U. S. Army, Nov. 1940, v. 18, p. 910–912).

There were 20 cases with metastases to the lumbar spine—an incidence of 38.5 per cent for all cases. Two cases showed microscopic evidence of metastasis but no gross lesions. By a comparison of the *x*-ray films, the gross specimens and the pictures, it is obvious that destructive lesions must be very extensive to give *x*-ray changes, while the osteoblastic lesions show up early. Of the 20 cases, the *x*-rays in 10 were negative. In the 10 with *x*-ray changes there were 5 which were osteoblastic in type. Thus a negative *x*-ray of the spine in a metastatic survey is of very limited significance.

Tumors of the spine present a number of peculiarities because of the close relationship of this portion of the skeleton to the nervous system and because of the persistence of a primitive skeletal tissue, the notochord. In

Metastatic Carcinoma of the Prostate.—The symptoms and roentgen appearance of pelvic metastases from prostatic cancer may simulate those of Paget's bone disease. With either condition the prostate may be insignificantly enlarged and serum acid phosphatase very little increased.

Oelbaum outlines three possible aids to differential diagnosis:

1. Serum acid phosphatase derived from prostatic tissue is always destroyed when alcohol is added to the specimen, whereas acid phosphatase from other sources is stable.

2. Anemia due to carcinomatosis may be associated with immature red cells and a few immature white cells of the myeloid series in the peripheral blood.

3. Estrogenic therapy relieves bone pain produced by metastatic lesions, reduces serum acid phosphatase, and occasionally eliminates immature cells.

Six cases of prostatic cancer strongly resembling Paget's disease were diagnosed by the suggested clues.

The chief complaint is, generally, backache, particularly the lumbar region, with radiation down the limbs. The cervical spine and arms may be involved. If the legs are affected, pain is commonly bilateral, constant, severe, and not of sciatic distribution.

The prostate may be hard and nodular or slightly enlarged and firm, giving the impression of benign hypertrophy. Symptoms of urinary obstruction may be unnoticed, or nocturia and dysuria may have continued for some time with no recent exacerbation.

Serum acid and alkaline phosphatase are estimated by the Gutman and King-Armstrong technics, respectively. In some cases initial serum acid phosphatase exceeds 10 units; in others the figure is less or even normal. Whatever the total value, the prostatic fraction is invariably inactivated by alcohol, with loss of several units.

Paget's disease is frequently associated with normal acid phosphatase, and alcohol does not affect either low or high values.

Anemia due to carcinomatosis often develops early and progresses rapidly. Immature cells may be enlarged, possibly as a consequence of myeloid metaplasia.

Roentgenograms are so puzzling that a diagnosis of Paget's disease may be made even when cancer is recognized. Usually, the pelvis and lumbar spine show generalized osteoporosis and increased trabeculation, but radiologic changes may not appear until many months after the development of the metastatic symptoms.

Stilbestrol therapy has produced spectacular results. Pain is relieved in less than a week, appetite and weight return, and the prostate usually shrinks, though obstructive symptoms ordinarily persist. Serum acid phosphatase is reduced, at times to normal levels, and alkaline phosphatase may rise slowly, then fall.

Estrogens are merely palliative, however, and the treatment will eventually fail.

With Paget's disease, acid phosphatase is unaffected by estrogens, and alkaline phosphatase remains stationary or gradually decreases.

Treatment of Malignant Tumors of Vertebræ.—Non-operative treatment includes rest in bed, traction, irradiation with either the roentgen ray

sacrolumbar region and produces sclerosis of bone These multiple lesions of the spine in adults must be differentiated from multiple myeloma which produces multiple circular defects with a tendency to pathologic fracture and collapse Involvement of the spine in Hodgkin's disease, lymphosarcoma and leukemia may simulate metastatic carcinoma

Benign giant-cell tumor and osteochondroma are the most common benign tumors of the spine Giant-cell tumor usually affects the spine of the young adult below the cervical region, tends to involve the neural arches and produces a trabeculated lesion outside of the body of the vertebra The healing phase of this condition produces bone cysts, which may also complicate von Recklinghausen's disease associated with parathyroidism and demineralization of the entire spine Osteochondromas may occur in any portion of the spine The neural arches are affected by an osseous growth with a clearly demarcated osseous shadow visible in the roentgenogram Hemangioma of a vertebra is rare and produces characteristic vertical striations or well-ordered radiating spicules of bone without collapse of the body of the vertebra

Osteogenic sarcoma of the spine, including chondrosarcoma, osteolytic sarcoma and sclerosing sarcoma, may be secondary to multiple exostoses or to Paget's disease These sarcomas show a wide age distribution Chondrosarcoma of the spine tends to involve several vertebrae and produces characteristic calcified paravertebral shadows The roentgenogram in a case of sclerosing sarcoma shows irregular formation of a new bone in the soft parts Osteolytic sarcoma is less characteristic in the roentgenogram and produces a rapidly extending lesion of osseous destruction, with infiltration of the soft parts Chordoma affects either the spheno-occipital or the sacrococcygeal region of the spine of an adult and produces a destructive lesion which increases gradually

Twelve undifferentiated neuroblastic tumors—sympathicoblastomas—involved the spine in Geschickter's series Such a tumor is usually situated in the lower part of the thoracic or in the lumbar region It destroys bone and produces a paravertebral shadow It tends to metastasize to the regional lymph nodes and to other bones On microscopic examination it is often mistaken for Ewing's sarcoma Like Ewing's sarcoma it responds to irradiation The spinal tumors previously classed as Ewing's sarcomas were thought on further study to be sympathicoblastomas

A glial or nerve sheath tumor of the spinal cord may involve the vertebral column A meningeal tumor usually affects the thoracic or the cervical region and may be visible in the roentgenogram, either because of erosion of bone or because of calcification in the tumor A neurinoma or neurofibroma of a spinal nerve root more often causes erosion of bone than does a meningeal tumor Neurinoma is most common in the lumbar and sacral regions This benign tumor attached to a nerve root may slowly erode bone, the pedicle, the laminae and the body of the vertebrae in the order mentioned Erosion is more rapid and more pronounced with a malignant nerve sheath tumor affecting the roots of the spinal nerves Glial tumors producing changes in bone are rare They are usually primitive neuro epitheliomas or ependymomas In the sacrococcygeal region a benign or malignant teratoma may erode bone

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With Paget's disease acid phosphatase is unaffected by estrogens, and alkaline phosphatase remains stationary or gradually decreases

Treatment of Malignant Tumors of Vertebræ —Non-operative treatment includes rest in bed traction irradiation with either the roentgen ray

or radium (which usually relieves the severe pain) and medicine—calcium is given intravenously, and vitamin D and dilute hydrochloric acid by mouth The mattress should be semi rigid The patient's *posture* in bed *should be comfortable* Special *frames* like the Stryker model are very helpful in turning the patient

Resection of the coccyx and the lower 4 sacral vertebræ has been accomplished in a patient with a large pulsating benign giant cell tumor originating in the sacrum The method employed entailed laparotomy, ligation of the hypogastric arteries and temporary occlusion of the common iliac arteries

Leddy advises that metastatic spread of carcinoma in bone be treated with large doses of "high voltage" roentgen rays In certain instances treatment with the appropriate hormones may be an adjunct to roentgen therapy

The results of treatment of metastatic lesions of bone depend on the radiosensitivity of the primary tumor Of the most common metastatic tumors of bone, it may be said that roentgen therapy is most satisfactory in the treatment of metastatic tumors which originate primarily in the thyroid gland Next to these tumors those which originate in the breast respond most satisfactorily The results are least satisfactory in cases in which the primary tumor is situated in the prostate or suprarenal gland

GLOMUS TUMORS

The normal glomus is a modified arteriovenous anastomosis situated in the deep layers of the corium or in the stratum reticulare Glomus tumors may be the cause of localized pain in any part of the skin surface Although they are most frequently found in the subpapillary layer of the nail beds they occur in other parts of the body including the back They are benign enlargements of the normally present glomus body, 1 mm to 2 cm in *diameter reddish in color* and consist of a *coiled arterio-venous anastomosis* surrounded by a plexus of nerve fibers

Excruciating local pain is the only complaint of the patient with such a tumor often induced by the slightest pressure The skin surface usually appears normal but a small bluish covering may be seen Perlow found that 1 cubic centimeter of 1 per cent procaine solution injected into the painful area will completely relieve the symptoms

Treatment consists of elliptical excision of the tumor-bearing skin and subcutaneous tissue

Every person who has any neoplasm removed should have *x* rays of his or her spine for future reference if, as and when backache appears This is especially true of tumors of the breast prostate uterus ovaries or thyroid

CHAPTER 30

INFANTILE PARALYSIS: ANTERIOR POLIOMYELITIS INVOLVING THE BACK

I SHALL not elaborate on the etiology, pathologic changes, symptoms and diagnosis of anterior poliomyelitis which are covered in my book published by W. B. Saunders Company. My purpose here is to discuss treatment, especially the treatment during the immediate acute stage and the surgical procedures that are available for the correction of the residual effects of the disease as it involves the back and allied structures.

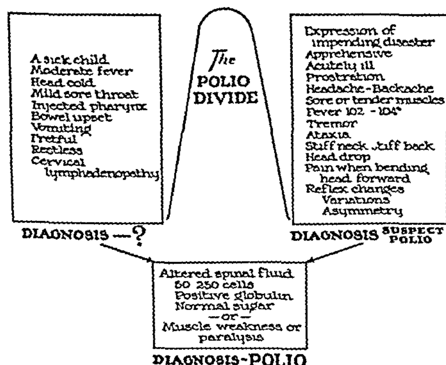


FIG 187 —The "Polio Divide" indicating symptoms, signs and spinal fluid findings in poliomyelitis. On the left, the signs and symptoms enumerated may occur in any one of many illnesses. On the right the signs and symptoms are highly suggestive of poliomyelitis. Below are shown the findings which clinch the diagnosis. (Lewin's Infantile Paralysis, courtesy of W. B. Saunders Company.)

I am a strong advocate of human convalescent serum in preparalytic cases and in those cases where paralysis is spreading or progressing. I also believe serum should be given to those patients whose fever continues persistently high, regardless of the condition of the muscles.

I am a strong advocate also, of the respirator in cases of weakness or paralysis of the muscles of respiration due to involvement of the anterior horn cells of the cervical spinal cord, the intercostals and the diaphragm.

It is evident, from the enormous number of controlled human observations, that the new Salk vaccine sponsored by The National Foundation For Infantile Paralysis, will practically eliminate paralytic poliomyelitis from the civilized world

Another "dead" vaccine has been produced by Levinson-Woolf Miltzer (Michael Reese Hospital, Chicago)

Still another has been developed by Sabin of Cincinnati who favors an attenuated virus vaccine

The Kenny treatment during the immediate acute stage is undoubtedly an effective local prophylactic measure in preventing or minimizing deformities and disabilities of the back, abdomen, neck pelvis and extremities

The principles upon which the treatment is based and the technic are taken from my article *

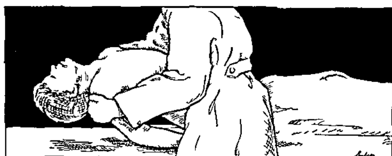
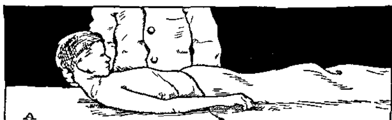


Fig 188 — Head drop —when the shoulders of a child with poliomyelitis are lifted off the bed the child s head falls backward (Lewin s Infantile Paralysis courtesy of W B Saunders Company)



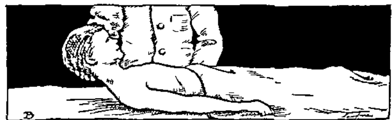


Fig 189 —*A* Normal child—examiner can flex child s head and neck approximating chin to chest *B* poliomyelitic child—examiner encounters resistance and cannot completely flex head (stiff neck or Caverly s sign) (Lewin s Infantile Paralysis courtesy of W B Saunders Company)

* The Illinois Medical Journal April 1942 p 281



Fig 190 — A Normal flexion of head and neck B poliomyelitic child—in attempting to flex head and neck is unable to approximate chin to chest note associated stiff back (spine sign) C poliomyelitic child—in attempting to touch chin to chest compensates for this inability by opening his mouth and dropping his chin (Lewin's Infantile Paralysis courtesy of W B Saunders Company)

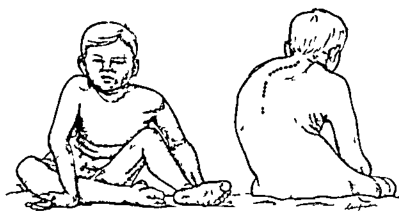


Fig 191 —Severe left thoracic right lumbar scoliosis with extensive paralysis of legs due to poliomyelitis Redrawn from photographs (Lewin's Infantile Paralysis courtesy of W B Saunders Company)

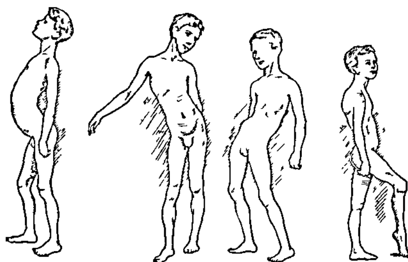


Fig 192 —Types of deformities and gaits characteristic residuals of anterior poliomyelitis A Paralysis of abdominal and back muscles B paralysis of abductors of right thigh C paralysis of flexors of pelvis and thighs D paralysis of dorsiflexors of right foot (Redrawn from Lovett)

Her theory is based on four main signs and symptoms *viz* (1) pain, (2) muscle spasm, (3) mental alienation, (4) muscle incoordination My interpretation of them is as follows

Her treatment is aimed at (1) the abolition of muscle spasm, (2) the substitution of mental "awareness" for the pathological "alienation" (3) the restoration of coordination of muscle activity

Her treatment includes (1) proper bed placement—natural rest position, (2) a foot board to preserve the "standing reflex," (3) hot fomentations to relieve pain and muscle spasm, (4) special analysis, classification and re-education of muscles, (5) passive movements, (6) concentration of active movements on the insertions of muscles and tendons

Hot Wet Packs —Hot wet packs are applied to all "muscles in spasm"

Application of Fomentations for Painful Abdominal Spasm —It is necessary to shorten the iliopsoas muscle a little by flexing the thigh at right angles to the body and to flex the leg at right angles to the thigh supporting

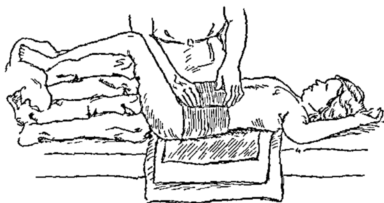


Fig 193 — Hot fomentations for abdominal and low back muscles in spasm Note flexion of thighs to relax psoas muscles (Lewin courtesy of Illinois Medical Journal)

it in this position and then to treat the muscle spasm by the application of hot fomentations (Fig 193)

Position of Natural Rest in Bed —Upon admission to the hospital the patient is placed upon a rigid bed to keep the body in correct alignment Boards are placed under the mattress a board is placed at the foot of the bed to maintain the sensation of contact both in the recumbent and erect positions and to re-establish the normal standing reflex, that is the inducement of the normal contraction of all standing muscles when the sole of the foot comes in contact with a hard surface

A small pad is placed under the knees and sometimes a padded roll is used to prevent the legs from rotating outward Patients are turned to the prone position for an hour twice a day In the face-lying position the feet are placed over the foot of the mattress so that they are at right angles to the lower part of the leg and the toes are in the clear The side lying position is not permitted The arms remain at the sides of the body A pillow for the head is permitted and after coordination has been re-established, the patient is allowed freedom of movement in bed

The mattress is pulled up toward the head of the bed and a flat foot board is placed at the foot with a space between it and the mattress. The patient's feet rest firmly against it at right angles with a free space under his heels. A towel or blanket is placed under the knees and tucked under the knees—preventing hyperextension of knees and external rotation of legs. Patients are not allowed to twist or roll or use hands or arms if shoulders, arms and abdominal muscles are involved.

The posture described is maintained, as far as possible, for the major portion of the twenty-four hours. A prone position is substituted for periods of one hour during the daytime. To prevent prolonged maintenance of one position, the patient is turned over at intervals and lies prone with his feet over the end of the mattress. Patients who have been alternately turned from the supine to the prone position do not develop visceral complications. All pressure, especially on bony points, is carefully less likely to form if the patient moves around, or is moved by apparatus. Wright's oscillating bed is very helpful.

OTHER MEASURES IN TREATMENT

Underwater Gymnastics.—Exercises in warm water have proved especially valuable. The combination of hot fomentations, movements in the water tank and muscle re-education exercises on the table is ideal.

Tank Treatment.—Blount and Hubbard devised an excellent tub which can be used as soon as the acute pain and sensitiveness have disappeared. Because the tub is only 16 inches deep, the helpless patient is not so afraid of drowning as he is in a deep tank or pool. I designed a unit which has proved satisfactory (Fig. 195). (Another efficient tub has been designed by Currence.)

Massage.—Massage should be used only under proper direction. Irreparable harm may be done by irregular and unqualified practitioners.

The principles of massage prescribe the following: (1) Never cause pain. (2) Make the patient comfortable by the use of pillows or rolls to furnish support in order that the muscles may be relaxed. (3) Do not cause fatigue. Massage that is too heavy or too long continued is as tiring as too much exercise. From five to ten minutes is sufficient for each limb. (4) Use gentle but firm, slow, steady pressure in all strokes.

One must be cautious in avoiding the improper attitudes often assumed in carrying patients with poliomyelitis. They predispose to muscle imbalance, kyphosis, flexion of hips and knees and talipes equinus.

Teaching the Patient to Walk.—Patients are first taught to balance themselves between parallel bars of walking-cane height, then to take steps of the proper length with the proper transfer of body weight, still using the bars, which give them a greater sense of security than crutches do. As soon as a sense of balance permits, patients learn to use crutches or canes, and periods of walking are increased to four a day. The duration of each walking period depends entirely on the extent of the disability and the endurance of each patient.

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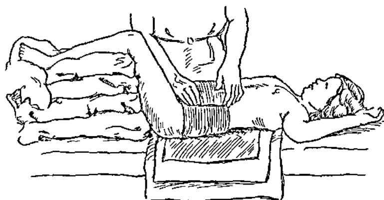


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Aids to Locomotion *Walkers* Metal frames on wheels can be used as "walkers"

Crutches —Crutches must be of such a length and the hand rests so spaced that the weight of the body comes on the hands and not on the axilla The axillary rests should be padded or made of rubber The patient must always have one crutch in front of him to prevent him from falling The correct procedure is first place the right crutch forward second place the left foot forward then the left crutch and finally the right foot In simpler terms first a crutch and then the opposite foot All steps with crutches and feet should be of equal length instead of a long step followed by a short one (Fig 196) Stair climbing should be taught gradually, since any new effort may cause fatigue

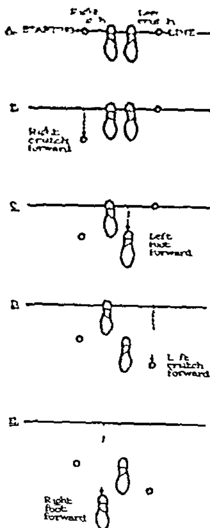


Fig 196 —Proper method of progression using two legs and two crutches (Lewin's Infantile Paralysis courtesy of W B Saunders Company)

These achievements determine the difference between dependence and independence for the afflicted person A patient with paralysis below the waist who has one good arm and one arm good enough to hold a crutch, given at least fair intelligence can be taught to walk by means of Lovett's tripod method If the crutches are placed apart and slanted well forward at their lower ends they form the two anterior legs of a tripod while the third and posterior leg is formed by the body of the patient inclined forward at its upper part with the feet and legs well behind I have prescribed crutches of unequal length in a few cases

Stationary Bicycle Riding —A valuable exercise during the latter part of the subacute stage is stationary bicycle riding The patient should ride forward and backward with and without friction on the back wheel tire The handle-bars seat and pedals should be adjusted to the patient While the patient is riding, his naked back should be carefully observed A back support such as a Taylor spine brace or a Hoke corset may be worn

PARALYTIC SCOLIOSIS

Fascial Transplants about the Shoulder —For the purpose of stabilizing the scapula and thus preventing or minimizing deformity of the chest and the cervical region, and improving the function of the muscles of the upper extremity, fascial transplants have proved useful to Dickson for two types of abnormality (1) paralytic scoliosis with drop-shoulder and

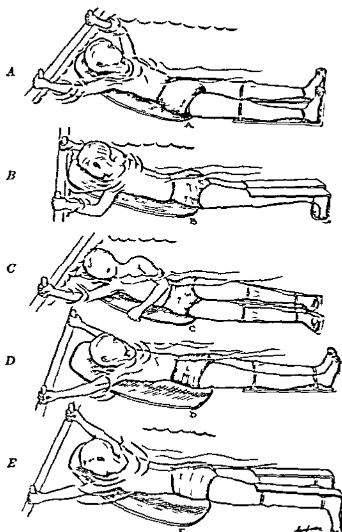


FIG 194 —A Supine on plinth *B* prone—arms at right angles *C* side-lying on plinth—one hand on bar one hand on edge of plinth *D* arms wide—plinth under pelvis but pelvis not touching *E* prone—arms extended (Redrawn from C L Lowman Technique of Underwater Gymnastics courtesy of American Publications Inc)



FIG 195 —Patient in Lewin Hubbard tub made of monel metal (Lewin s Orthopedic Surgery for Nurses courtesy of W B Saunders Company)

center of rotation of each scapula If an adduction contracture is present to any marked degree, the contracted structures should be thoroughly stretched, either before or at the time of the operation When there is marked weakness of the rhomboid muscles and only moderate weakness of the abductor muscles of the shoulder this operation is particularly helpful

Whitman Operation for Paralysis of the Serratus Magnus Muscle — The superior and vertebral borders of the scapula are exposed through an incision extending from the acromion process along the superior border, thence down the vertebral border Four holes are drilled through the scapula, one at each of the following points the superior border, the junction of the spine and vertebral border, the middle of the vertebral border and the inferior angle The spinous processes of the 4th, 5th, 6th and 7th thoracic vertebræ are also pierced with holes Strips of fascia lata are passed through these corresponding holes and sutured under tension as the scapula is retracted downward and backward After the wound is closed, a shoulder spica cast is applied, holding the arm abducted 45 degrees beyond a right angle After four weeks, the cast is removed and motion permitted

OPERATIONS ON THE SPINE, RIBS, ABDOMEN, PELVIS AND HIP

Operations on the Spine — Poliomyelitis is responsible for a large proportion of idiopathic scoliosis Operations on vertebræ are performed chiefly for residual scoliosis Preliminary correction of the deformity is accomplished by the Risser-Hibbs technic The number of vertebræ to be fused is determined by the character of the curvature the primary curve and the pivotal points

The chief spine operations for the after-effects of poliomyelitis are known by the names of Hibbs Albee and Delagenière-Lewin (see chapter on Scoliosis)

Operations on Ribs —In cases of extreme telescoping of the torso, the 12th and 11th ribs may drop below the crest of an ilium producing considerable pain and limitation of movement Tissue becomes pinched between crest and descended ribs In some cases resection of one or more ribs is advisable The technic consists of an incision parallel with the 12th rib Resection is accomplished with rongeurs

Operations on the Abdominal Wall — Lowman and Mayer reported several cases in which the action or at least the stabilizing effect on abdominal muscles was restored to some extent by the use of fascial strips sutured to healthy muscles and passing over to be attached at the insertions of the weak or paralyzed muscles or passing from one bony point to another These surgeons have indicated the following useful functional tests

Determination of weakness in the upper and lower recti and the abdominal oblique muscles is not difficult since Beevor s sign, or shifting of the umbilicus upward, downward or to one side or the other when the head is raised against light resistance and loss of muscle tone are fairly accurate guides

marked cervical curvature, (2) paralysis of the scapular muscles with asymmetry of the shoulder, deficient stability of the shoulder girdle and high thoracic curve

His objective was twofold (1) to elevate the dropped shoulder, and (2) to provide a fixator action against the pull of the unparalyzed muscles on the convex side of the cervical curve which is concave toward the side of the depressed shoulder To accomplish these two objectives he employed two fascial strips one was passed from the spine of the scapula to the cervical muscles on the concave side of the cervical curve, the second was passed from the spine of the scapula to the spinous process of the 1st thoracic vertebra

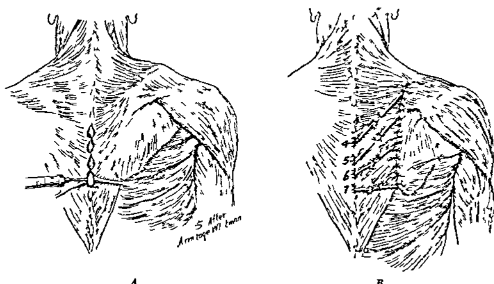


Fig 197 —Operation for paralysis of serratus magnus muscle (Armitage Whitman) *A* Exposure of displaced scapula and of spinous processes Holes drilled through vertebral border of scapula and spinous processes of 4th 5th 6th and 7th thoracic vertebræ *B* operation completed Strips of fascia lata have been passed through corresponding holes in scapula and spinous processes with scapula drawn downward and medially strips are tied under tension (Campbell s Operative Orthopedics —C V Mosby Company redrawn from Whitman)

Lowman's Interscapular Fascial Transplant —In some cases of paralysis of the serratus, Brockway has controlled the rotation of the scapula by running a fascial strip from the lower axillary border of the scapula forward and upward to the ribs This procedure combined with the interscapular transplant frequently establishes definite improvement in shoulder function The operation consists of tying the scapulæ together with fasciæ latæ Short incisions are made over both scapulæ along the vertebral borders at the level of the spines A subperiosteal dissection is done One end of the strip of fasciæ latæ which is about ¾ inch wide is passed through a hole gouged through one scapula 1 inch lateral to the vertebral border and just below its spine The fascia is sutured back on itself with silk, and the other end is passed subcutaneously to the opposite scapula and sutured in a similar manner There should be sufficient tension so that the vertebral borders of the scapulæ are almost parallel to each other Anchoring the two scapulæ does not restrict rotation because the chosen point is the

umbilical stem was grasped with strong forceps and pulled downward as far as possible while the lower end of the fascial strap was forced into the osteoperiosteal slot below and firmly sutured with silk. Sutures of silk were similarly placed on each side at intervals of 1 or 1½ inches. Then the aponeurosis was laid back and sutured in place with chromic catgut. Before closing another strip was fastened at the same location above and passed subcutaneously in the fat downward and outward to the right ilium at the

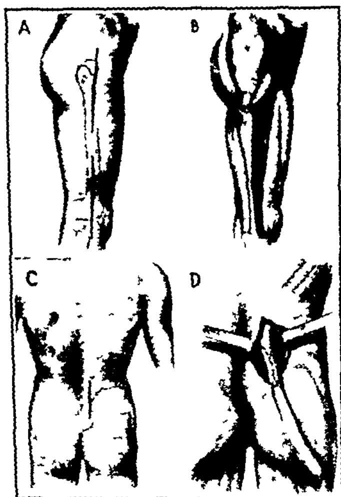


Fig. 199.—Erector spinae transplant. A, skin incisions in the lateral aspect of the thigh. B, the fascia lata to which is attached the tensor fasciae latae has been passed beneath the vastus lateralis and sutured subperiosteally to the femur. C, skin incision in the lumbar region and D, the free end of the fascia from the thigh has been passed beneath the gluteal fascia and sutured to the lateral two thirds of the erector spinae muscle which has been detached from its origin. (Barr.)

point of attachment of Poupart's ligament. Here it was attached periosteally as before, after all the slack allowed by the shortened upper left oblique muscle was taken up. Lowman in recent cases has run the narrower strips ½ to 1 inch, through the tunnel in subcutaneous tissue and has used a running fascial band from active abdominal muscles to the leg to transmit power farther down.

For paralysis of the upper rectus and the oblique muscles, the fascial strips are attached to the lower active recti below the umbilicus, one strip being passed straight upward within the sheath of the rectus and attached

Determination of weakness in the quadratus lumborum the latissimus dorsi, the serratus anterior, the rhomboids, and at times the trapezius is not so readily made Mayer described the following test for determining the power of the quadratus lumborum The patient, in the supine position clasps the examiner around the neck with both hands, lifting the trunk clear of the table The examiner flexes the patient's body toward the side, then requests the patient to swing the body back to the natural position as the examiner palpates the lateral abdominal muscles

Lowman has demonstrated that restoration of lost power in the presence of partial paralysis of the abdominal muscles is possible and practical Decided improvement in stabilization of the trunk on the pelvis can be obtained There is a specific relation between abdominal paralysis and paralytic scoliosis

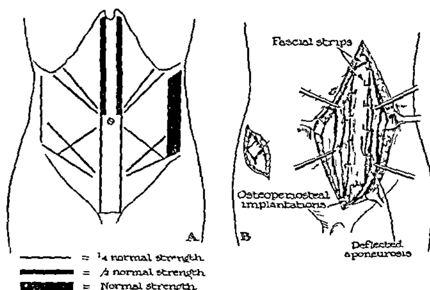


FIG 198 —Lowman operation for paralysis of abdominal muscles (Lewin s Infantile Paralysis courtesy of W B Saunders Company)

Fascial Transplantation for Paralysis of Lower Recti and Right Oblique Muscles —Lowman described an operation using fascia lata, fastening it by an osteoperiosteal attachment to various structures ribs, muscles or pubes The transplanted fascia lata looks like a falciform ligament or *Poupart s ligament A strap of fascia about 2 inches wide is used to repro* duce the external oblique muscle

Lowman proposed an operation which consisted of opening the abdomen in the midline from a point 2 inches above the umbilicus to the symphysis pubes Lateral dissection was made to uncover the rectus aponeurosis on the right side This was opened and reflected showing the attenuated remains of the paralyzed lower half of this muscle A strap of fascia lata was transplanted extending from the lower 2 inches of the healthy upper rectus to the symphysis into which it was inserted through an osteo periosteal slot raised from the bone The strap 1 inch wide and 9 inches long, was sutured with silk above for 2 inches then with the operating table lowered in the middle to slacken the pull on the abdominal wall the

CHAPTER 31

METABOLIC AND DEFICIENCY DISORDERS

Glandular and Circulatory Disturbances That Can Affect the Back

RICKETS INVOLVING THE BACK

Rickets is a systemic disturbance of metabolism due to a deficiency of vitamin D, which is manifested by imperfect calcification of osteoid tissue. It occurs usually between the sixth and twenty-fourth months of infancy. If not corrected, it results in softening and bending of the bones, enlarged epiphyses, deformities of the thorax and back and other defects.

Rickets occurs more frequently in cities than in rural districts. Premature infants are especially susceptible.

The striking pathological changes of rickets are imperfect endochondral ossification, excessive resorption of the inner layers of the bones, fibrous tissue transformation of bone marrow and osteoid tissue formation due in part to decalcification and in part to metaplasia of cartilage and fibrous tissue.

Etiological Factors.—Rickets is due to an inadequate supply, or defective utilization of vitamin D, the filtering out from the sunlight of the ultraviolet rays of the shorter wave lengths, by window glass, clouded skies and smoke palls over manufacturing cities, and heavily pigmented skin. Congestion of population, polluted air, damp unclean living quarters, frequent exposure to infection, prolonged illness, lack of exercise and unhygienic conditions are intensifying factors. Thus, the deficiency may be due to inadequate diet, defective utilization by the body of, or insufficient exposure to, sunlight. Sunlight irradiates the sterols in the skin, giving the body a direct source of vitamin D.

Role of Vitamin D.—Deficiency of the fat-soluble vitamin D is the predominant factor in rickets. Cod-liver oil, a natural specific for rickets, contains 200 times as much vitamin D as butter. Other natural sources of the vitamin are egg-yolk and various fish oils. Foods can be endowed with the antirachitic property by being irradiated with ultra-violet rays. The substance "activated" is an ergosterol. The absence of sunlight does not produce rickets if the nutritional requirements are met.

Role of Calcium Phosphorus Balance.—With the development of human rickets, the normal amounts of calcium and phosphorus in the blood are lowered from 10 to 11 mg. and 5 to 6 mg. per 100 cc. of blood respectively to approximately 8 mg. and 2.5 mg. A child may get ample calcium in its food and still have bones which are poor in this element.

An excess of either calcium or of phosphorus in the diet influences unfavorably the absorption of the other from the intestine.

to the rib margins, and the other strip passed outward to the costal border and fixed at a slightly lower level

Operations involving the pelvis are described in Chapter 38

One of the most intractable sequelæ of poliomyelitis is a complex deformity involving the knee, the hip and the lumbosacral portion of the spine It was described by Barr The hip deformity is characteristically one of flexion and abduction The knee may be in flexion and valgus with external torsion of the lower leg on the femur The lumbosacral region of the spine is in lordosis, and if only one extremity is involved there will be in addition to the lordosis a pelvic tilt, the contralateral iliac crest being high The affected leg is abducted the unaffected leg is adducted, and there is a lumbar scoliosis, convex toward the affected side

Transplants of the tensor fasciæ latæ and of the erector spinæ muscle were combined into one operation by Groves and by Ober Barr reviewed the records of 50 consecutive patients on whom erector spinæ transplants have been done and re-examined about one third of the patients

SPASTIC PARALYSIS INVOLVING THE NECK, BACK OR PELVIS

The reader is referred to special treatises on the subject The *Prophylaxis* is not known

Remedial Measures include

Barbiturates	Priscoline
Artane	Demerol
B_1	Pyromen
Folic acid	B_{12}
Rehabilitative	Psychology
Tubocurarine plus immediate physical stretchings	
Myanesin—Tolserol—Mephenesin—Tolseram—Mephate	

Curare is a very useful drug but must be used with great caution and only by a highly trained person

ANTONUCCI S POSTEROMEDIAL CORDOTOMY

In the report to the 32d Congress of the Italian Society of Orthopedics Zanoli spoke in favor of Antonucci s posteromedial cordotomy in the treatment of spastic paralysis Through a laminectomy of the XIth and XIIth thoracic vertebræ the dura is opened and, with a lumbar puncture needle from 10 to 20 injections are given into the tract and an equal number in the bundle of the opposite side but at a level 1 or 2 centimeters lower Zanoli has operated upon 12 patients using this method The immediate results seemed very favorable with a diminution of the hypertonia immediately

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An excess of either calcium or of phosphorus in the diet influences unfavorably the absorption of the other from the intestine.

Under the influence of ultra-violet rays or of irradiated foods or those naturally containing the fat-soluble vitamin D, the inorganic phosphorus in the serum is increased to normal or slightly above, and fresh deposits of calcium appear in the bones

Symptoms —The constitutional symptoms are restlessness, excessive perspiration, digestive disturbances constipation with flatulence, impairment of the circulation, bronchitis and generalized muscular weakness The child's tissues are tender to pressure, and some of its joints may be sensitive to movement The skeletal muscles and ligaments are relaxed The ability to stand and walk is delayed, and movements are slow The skeletal signs of rickets appear in various bones at the time of their most rapid growth In the first year, the chief manifestations are in the bones of the thorax, in the second year and at puberty in the bones of the extremities

Roentgen ray Observations —The roentgen appearances of the long bones are characteristic The vertebræ show wedging, and decalcification with variations in normal curves, usually a long round kyphosis

Diagnosis —The diagnosis of rickets is based on the history the physical findings, the roentgenograms and the blood tests The disease must be differentiated chiefly from congenital syphilis and scurvy, but especially from syphilis

Treatment —The routine treatment includes fresh air, sunshine and a liberal diet especially rich in vitamin D supplemented by exposure to ultra-violet ray lamps and the administration of synthetic or natural concentrates of vitamin D According to Vollmer rickets and tetany can be cured promptly by the oral administration of a single dose of 600,000 international units of vitamin D in milk

Some rachitic deformities do not correct themselves automatically and require specific treatment, which includes special curved Bradford frames, braces special foods and cod liver oil

OBESITY

Obesity may be an important consideration in backache and sciatica, especially for mechanical and metabolic reasons and particularly in the presence of sacro iliac lesions and vertebral arthritis After injury to the back, obesity may prolong discomfort and disability A chronic painful back often ceases to be troublesome when a person who has been overweight brings his weight down to normal by diet

Body weight represents the balance of three factors (1) the amount of food ingested, (2) the amount of body heat lost by radiation, and (3) the amount of muscular work done The obese person stores body fat whereas normal and thin persons use it up The storage of fat is primarily a feature of metabolic bookkeeping—an indication of the imbalance between energy intake and the requirements of food fuel Obesity is invariably the result of overeating

Gain or loss of fat is a matter of physiological bookkeeping representing the balance between supply and demand in the organism

There are eight important factors in obesity (1) heredity (2) excess of food, (3) endocrine causes (4) water metabolism, (5) constipation, (6) lack of exercise, (7) physical therapy, (8) will power

The overweight child of today is the overweight adult of tomorrow Veeder advised against a marked reduction of the overweight child, recommending holding the weight and letting the child 'grow into it' He promises that the diet can be increased as exercises increase and more fuel is consumed

Mining said, 'Pigs would live longer if they didn't make such hogs of themselves' McLester found that the appetite in cases of obese persons is as a rule perverted

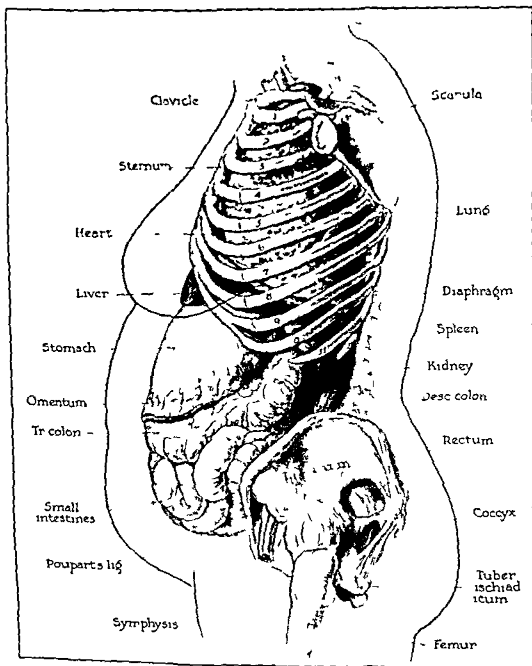


Fig 200 — Viscera in an obese woman left side view (Courtesy of S H Camp and Company)

Under the influence of ultra-violet rays or of irradiated foods or those naturally containing the fat-soluble vitamin D, the inorganic phosphorus in the serum is increased to normal or slightly above, and fresh deposits of calcium appear in the bones

Symptoms —The constitutional symptoms are restlessness, excessive perspiration, digestive disturbances constipation with flatulence, impairment of the circulation, bronchitis and generalized muscular weakness The child's tissues are tender to pressure and some of its joints may be sensitive to movement The skeletal muscles and ligaments are relaxed The ability to stand and walk is delayed, and movements are slow The skeletal signs of rickets appear in various bones at the time of their most rapid growth In the first year the chief manifestations are in the bones of the thorax in the second year and at puberty in the bones of the extremities

Roentgen-ray Observations —The roentgen appearances of the long bones are characteristic The vertebræ show wedging and decalcification with variations in normal curves usually a long round kyphosis

Diagnosis —The diagnosis of rickets is based on the history, the physical findings the roentgenograms and the blood tests The disease must be differentiated chiefly from congenital syphilis and scurvy, but especially from syphilis

Treatment —The routine treatment includes fresh air, sunshine and a liberal diet especially rich in vitamin D supplemented by exposure to ultra-violet ray lamps and the administration of synthetic or natural concentrates of vitamin D According to Vollmer, rickets and tetany can be cured promptly by the oral administration of a single dose of 600 000 international units of vitamin D in milk

Some rachitic deformities do not correct themselves automatically and require specific treatment which includes special curved Bradford frames braces special foods and cod-liver oil

OBESITY

Obesity may be an important consideration in backache and sciatica, especially for mechanical and metabolic reasons and particularly in the presence of sacro-iliac lesions and vertebral arthritis After injury to the back obesity may prolong discomfort and disability A chronic painful back often ceases to be troublesome when a person who has been overweight brings his weight down to normal by diet

Body weight represents the balance of three factors (1) the amount of food ingested, (2) the amount of body heat lost by radiation, and (3) the amount of muscular work done The obese person stores body fat, whereas normal and thin persons use it up The storage of fat is primarily a feature of metabolic bookkeeping—an indication of the imbalance between energy intake and the requirements of food fuel Obesity is invariably the result of overeating

Gain or loss of fat is a matter of physiological bookkeeping representing the balance between supply and demand in the organism

There are eight important factors in obesity (1) heredity (2) excess of food, (3) endocrine causes, (4) water metabolism, (5) constipation (6) lack of exercise (7) physical therapy (8) will power

The overweight child of today is the overweight adult of tomorrow Veeder advised against a marked reduction of the overweight child, recommending holding the weight and letting the child grow into it He promises that the diet can be increased as exercises increase and more fuel is consumed

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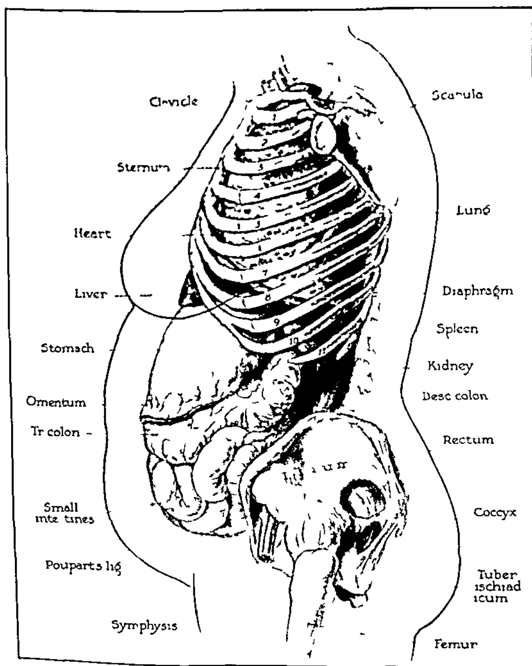


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Geist emphasized the fact that practically the entire contents of the abdominal cavity are attached in some way or another to the spine and that the weight of the fat pendulous abdominal wall is borne by the spine He found that for backaches of various kinds, lumbosacral and sacro iliac strains, vertebral insufficiency, spondylolisthesis, round shoulders and postural defects, weight reduction plays an important part in giving the patient comfort

Often 10 or 15 extra pounds may cause trouble Their removal gives relief Excessive weight in itself may be the cause of backache Obese patients become better surgical risks after weight reduction A gain in weight may occur solely because water is being added to the body and weight may diminish in spite of overfeeding because a depletion of water is also taking place

Diet —Treatment of obesity depends primarily on diet, which must be low in calories but must provide for adequate proteins vitamins and minerals The psychotherapy needed to overcome the disorder of appetite is important Physical measures are massage and exercises in the open air, including walking, tennis golfing, bicycle riding, rowing and other sports Jumping the rope tap dancing swimming and setting-up exercises are valuable There are many preparations that curb the appetite especially benzedrine and dexedrine

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The chief essential mineral elements are calcium, phosphorus, iodine and iron Calcium is found in cheese egg-yolk milk bran and green vegetables phosphorus in cheese egg-yolk milk, bran and oatmeal iodine in sea-foods and a few leafy vegetables iron in egg-yolk, meat liver, oatmeal and green vegetables

Vitamins aid growth improve appetite help the body to metabolize food and to prevent certain diseases Their study is one of the most recent and interesting in all medicine and surgery The word "vitamin' was coined in 1911 by Funk who separated a potent extract from rice polishings Foods furnish ample amounts of vitamins Milk is especially rich in vitamins A and G with a liberal amount of vitamin B and smaller amounts of vitamins C D and E fruits and vegetables are the most important source of vitamin C and furnish at the same time liberal amounts of vitamin B while several of them also make appreciable contributions of vitamins A, D and G Egg-yolks are rich in vitamins A B D and G Pineapple juice contains vitamins A B and C

PAGET'S DISEASE OF THE SPINE

Brailsford found 12 cases in which Paget s disease had been subjected to roentgen studies because of osteoarthritis of the spine or stone in the urinary tract The deformities in the lumbosacral spine due to Paget's

disease are recognized only after the bones have become softened and bowed owing to the weight of the trunk. The roentgen appearance is characteristic and the structure of the lamellae appears to be coarser than normal. Later on the bones show irregular ill-defined dense islands.

The cause is unknown. The symptoms are generally arthritic. The patient shows a simian appearance with decrease in height, rounded kyphosis and bowed legs. The symptomatic treatment is in general similar to that of arthritis. In 1940 Helfig advised aluminum acetate internally but I have not had any experience with it.

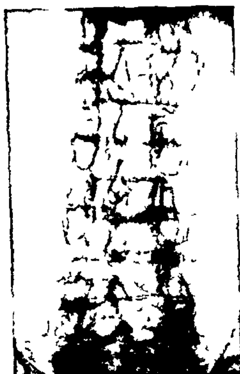


Fig. 201.—Parathyroid vertebral osteosis.

ACROMEGALY AFFECTING THE SPINE

Acromegaly is considered to be caused by pituitary adenoma. The onset is insidious covering one, two or three decades. The chief symptoms are rheumatic, with generalized and localized muscle weakness. Impotence may be an early symptom. The lumbar curve is shortened. The roentgenray reveals destruction of the sella turcica. The vertebrae become flattened (platyspondylia). Treatment includes support, physical therapy, the giving of calcium, vitamin D, vitamin B_1 for pain and dilute hydrochloric acid for achylia, roentgen therapy, radium treatment to the pituitary gland and operation on that gland.

PARATHYROID GLAND LESIONS

Among the favorite sites of pathological changes found in parathyroid disturbances, are the vertebrae and spinal muscles.

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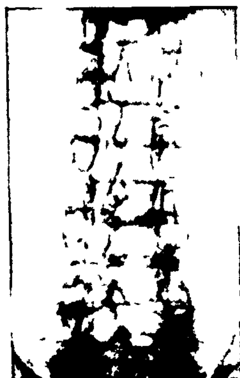


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lesion is sealed with tape for two or three days at a time which enhances granulation and healing When the tape is removed the secretion is wiped off and more tape is applied Bismuth violet locally, is effective Uhlmann recommended local application of Vaseline irradiated with Radon B Aeroplast is very helpful Surgery may be necessary



FIG 202 —*A* Vertebral destruction of 12th thoracic and 1st lumbar vertebræ due to aneurysm of aorta *A* Antero osterior projection *B* lateral view

OSTEOMALACIA OF THE VERTEBRÆ

In osteomalacia the bones become soft and flexible There is a predilection for the vertebræ Collapse of the back is usually associated with kyphosis and a striking reduction in the height of the body due to shortening of the trunk and bending of the long bones Deformity of the lumbosacral region of the spine due to osteomalacia is caused by compression of the softened lumbar vertebræ sacrum and pelvis The weight of the trunk forces the lumbar vertebræ and sacrum forward and all the pelvic bones bend under the pressure The trunk is thereby shortened The transverse furrows encircling the lumbar region indicate this

Subjective symptoms are pain in the back and loins sometimes occurring in acute attacks which may be due to spontaneous or pathological fractures

The characteristic effects are osteoporosis and muscle weakness followed by deformity of the back usually kyphosis

Treatment includes parathyroid extract, calcium, vitamin D, support and operation

Adenoma or Hypertrophy —Lahey's indications for removal of the parathyroids are (1) decreased height of the patient (2) increased rounding of the back, (3) radicular pains, (4) increased calcium in blood, (5) decreased phosphorus in blood, (6) roentgen shadows in the kidney

Orthopedic treatment may proceed concurrently with treatment of the parathyroids

SKELETAL CHANGES IN CRETINISM

Human growth is greatly influenced by the endocrine glands The findings in cretinism are evidences of a retardation of development with persistence of an immature state of the skeletal system, associated with irregularities of ossification In the spinal column Gold found there was a notable increase in the height of the intervertebral disks with a corresponding decrease in the height of the vertebral bodies There was also a persistence of the segmentation of the sacrum a further indication of skeletal immaturity Characteristically in cretins the bones preformed in cartilage grow slowly in length the epiphyses remain flat ossification within the epiphyses takes place irregularly and from several centers which are delayed in their appearance and the epiphyseal plates persist long beyond the normal period Also when complete ossification of the epiphyseal plate does occur the transverse trabeculae of bone, which mark the site of the obliterated plate are thicker and more prominent than normally The epiphyseal growth plates may persist even into the fifth and sixth decades of life

CIRCULATORY, VASCULAR AND PRESSURE DISTURBANCES IN RELATION TO BACK DISORDERS

The relation of circulatory disturbances to back disorders is poorly understood There is a theory that passive congestion causes arthritic changes in the vertebræ

Calcified aorta is a common finding in elderly people who complain of backache It may be simply coincidental The proximity of the lymphatic channel to the vertebræ is thought to be a source of infection especially tuberculosis

Decubitus, or pressure sores may occur over the heels sacrum and buttocks as a result of local impairment of nutrition Lesions of this type occur most frequently when the resistance of the tissues has been lowered by age, chronic disease, injury or nerve involvement They are initiated by pressure and often aggravated by some slight irritation In bedridden patients they are due to continuous or intermittent contact with the bed sheets A fresh 5 per cent aqueous solution of tannic acid is a simple and effective application I have had success with elastic adhesive tape The entire

absence of material required to make bone. It is analagous to the difference between "curbstone" bone and "sponge candy" bone.

Osteoporosis is found most frequently in patients of middle age or over. It is found most often in women well beyond the climacteric. Osteoporosis following a fracture of a vertebra in elderly people is difficult to treat. One is confronted not only with senile osteoporosis but also with the osteoporosis of disuse due to immobilization. Examination of the bone marrow obtained by sternal aspiration is often helpful.

The commonest metabolic disorder of bone is osteoporosis resulting from gonadal deficiency.

Because of the osteoblastic hypoplasia, too little nitrogenous bone matrix is formed, but calcium metabolism and bone resorption are normal, and serum alkaline phosphatase is not increased. Lesions tend to involve the pelvis and vertebra, which may collapse and compress nerve roots.

Most patients with the disease are elderly women, although eunuchoid men or young women with ovarian agenesis may be affected.

Osteoporosis has been known to develop in persons taking potassium thiocyanate for hypertension.

It may follow immobilization in a plaster cast used in the treatment of an injured back. Osteoporosis may develop without apparent cause.

Vertebral osteoporosis should be considered a physical finding revealed by the roentgen ray, but not as a diagnosis. The causes are senility, trauma, infections and glandular disturbances. The symptoms are pain, weakness, inability to go up and down stairs, inability to step up onto the sidewalk curbs and inability to cross legs while sitting. Kyphosis and shortening of the torso are usually present by the time the patient consults a physician. The roentgen ray findings are decreased density of the vertebræ with loss of calcium in the bodies, so that the outlines appear more distinct than normal. Compression of the vertebræ occurs early and wedging may follow shortly.

Some of the causative factors are:

1. Loss of sex hormones (estrogen and testosterone).
2. Lack of use (stress and strain is the normal stimulation for bone building).
3. Lack of protein (nitrogenous) foods.

Freyberg and Levy believe that osteoporosis is due to an insufficient production of osteoid tissue. The most common causes are:

1. Failure of stimulation of osteoblasts due to postclimacteric deficiency of steroid hormones.
2. Decrease in stimulation of osteoblasts due to reduced physical activity, especially of muscles.
3. Protein deficiency which depletes the bone matrix.
4. Old age atrophy of the bone matrix.

POSTMENOPAUSAL OR SENILE OSTEOPOROSIS

Postmenopausal or senile osteoporotic states show marked bone absorption. The primary defect is one of failure of bone matrix formation rather than of calcium and phosphorus deposition. The probable causes include

Roentgenograms reveal calcium deficiency of the skeleton, most marked in the spine The vertebræ may be narrow, with biconcave excavations or may be more irregularly deformed (fish vertebræ) Owing to collapse and shortening of the lumbar spinous processes a secondary osteo arthrosis of those processes may be demonstrated radiographically

The lesions may be the result of diet poor in calcium and vitamin D, or may result from disease of the digestive tract, gastric achylia or from abuse of laxatives which disturb the absorptive processes, producing achylic osteomalacia and osteomalacia proper

The pathological changes in the decalcification of the bony framework cause reversion of the resulting organic matrix and medulla to fibrocellular connective tissue This tissue may then either degenerate and break up into debris and fat or develop into incompletely calcified cancellous bone

True osteomalacia according to Maxwell is a manifestation of rickets in a person whose bones have reached maturity Hence the associated shortage of vitamin D and in the majority of cases an actual calcium starvation

The fundamental process as explained by Hodges and Ledoux, is probably indentical with rickets of children where growth is of first importance, but the unusual calcium demands of pregnancy or lactation are absent It may also be identical with senile or famine osteoporosis, where diet deficiency is the sole factor

Osteomalacia may occur at any age but generally in women during the child bearing period However, women who have never been pregnant may suffer from it and occasionally the disorder attacks men When elderly people are affected the term "senile osteomalacia" is used The disease is found chiefly in famine districts or where peculiar religious or social prohibitions keep women away from sunlight

Treatment with calcium salts and vitamin D is effective since the pain and disability are generally improved or banished The treatment is also supportive plus an antirachitic diet including vitamins, especially vitamin D, and heliotherapy Cod liver oil phosphorus and viosterol are of value

In Rosenfeld s paper on senile osteoporosis he gave in addition to calcium and vitamin D subcutaneous injections of minimal doses of epinephrine which proved helpful

Stein believes that osteomalacia is due to a mineral-vitamin deficiency The causes include hyperthyroidism diabetes Cushing's Disease, hypogonadism disuse atrophy

He prescribes phosphorus calcium and vitamin D, plus protein except in the presence of kidney trouble During bed rest and immobilization one should prescribe less phosphorus calcium and vitamin D, but must give protein

OSTEOPOROSIS OF THE VERTEBRÆ

Osteoporosis is an intriguing subject Its causes, development, course and response, and resistance to treatment are not too well known Its etiology is bound up with bone metabolism Osteoporosis is due to a lack of osteoid material which is due either to inactive osteoblasts or to the

Hallahan was able to relieve symptoms with large injections of Vitamin B_1

Advanced cases of osteoporosis require back supports To conserve the calcium content of the body the diet should exclude fats and cereals which inhibit calcium absorption Vitamins C and D are recommended

Treatment includes the application of the roentgen ray or radium and the administration of calcium phosphorus, Vitamin D, dilute hydrochloric acid, and the ingestion of milk, nuts, prunes and apricots The most important aids in relieving pain are rest, a brace, a Hoke corset or a belt Roentgen or radium therapy is beneficial in relieving pain in the back and in the process of remineralization of the vertebrae *The mattress should be rigid* Thiamin chloride is given intravenously and subcutaneously in daily doses of 50 to 100 mg to control any neuralgic pain Calcium preparations should be given intravenously daily

There are several good preparations of combined hormones on the market including *Tylosterone Premarin with methyltestosterone and others*

Reifenstein and Albright report on the metabolic effects of steroid hormones They reduced the phosphorus and calcium losses Maximum effect was observed after 30 days The beneficial effect persisted for 30 to 50 days after the administration of sterones was interrupted

The following *medication is recommended*

1 Diethylstilbestrol 0 5–1 0 mg daily orally
2 Premarin 1 25 mg t i d orally,
3 Estradiol benzoate 1 66–3 32 mg three times a week intramuscularly,
4 Estradiol dipropionate 5 mg weekly intramuscularly
5 Testosterone, not above 300 mg per month (For women use methyltestosterone 10–20 mg a day orally)
6 Testosterone propionate, 10–25 mg intramuscularly weekly

Reifenstein and Albright do not advise a high protein diet I recommend a diet high in protein, plus milk (4–6 glasses a day) generous amounts of of cheese milk and Vitamin D up to 12 000 I U daily Reifenstein and Albright use a low sodium chloride diet for elderly patients in whom sterones may produce edema They also recommend interruption of the sterone feeding for 7 to 14 days each 4 to 6 weeks because of its carcinogenic effect

Most endocrinologists consider estrogens beneficial in postmenopausal or senile *osteoporosis For this purpose the administration of* diethyl stilbestrol, 0 5 mg to 1 mg daily is recommended or the use of natural estrogens such as estrone sulfate 1 5 mg daily or the therapeutically equivalent amount of the injectable estrogens Some clinicians administer testosterone propionate 25 mg once a week in order to prevent endometrial hyperplasia and painful breasts and to decrease the incidence of uterine bleeding caused by estrogens Orally given androgens are of equal value in an equivalent therapeutic dosage that is, about 5 to 10 mg of methyl testosterone daily by mouth

From his study of 7 women with postmenopausal osteoporosis Howard concluded the following

To improve metabolism, estradiol benzoate is injected intramuscularly in daily doses of 1 66 mg or 3 to 15 mg diethylstilbestrol is given by

(1) An inadequate amount of estrogens or androgens (or both) with a resulting deficiency of osteoblastic activity

(2) Menstrual disturbances in the female, usually a premature cessation, impotence and reduced sexual activity in the male

(3) Progressive general fatigue in association with extreme weakness of limbs and marked muscular atrophy of the upper extremities

Reifenstein and Albright list various types of bone atrophy associated with hypofunction of the osteoblasts in forming bone matrix Some of these are senile bone atrophy, Cushing's syndrome, idiopathic osteoporosis, acromegaly, and postmenopausal osteoporosis

Since the bone decalcification is due to a local lesion, treatment should be essentially local Measures to improve circulation should be emphasized *Massage contrast baths and exercises should be prescribed* The most important single factor is the establishment of normal function as soon as possible

Recovery of normal or nearly normal bone usually results if treatment can be successfully instituted, although recalcification is notoriously slow

The treatment includes protected functional use to the point of toleration combined with physical therapy measures, *i e*, protection plus support plus functional use

The diet should be well balanced and contain adequate calcium, for which milk is the best source Calcium preparations and even hypodermic injections of calcium may be given

Orally given calcium is not especially effective One would hesitate to prescribe this type of medication for an elderly person, because of the possibility of formation of renal calculi

NOTE Colloidal sulfur is said to check demineralization

Some investigators have reported on the use of aluminum acetate in syrup of tolu and honey One must be certain that there are no impurities of lead or aluminum subacetate in the aluminum acetate

Senile osteoporosis leads to considerable pain and disability Women are afflicted more often than men and the majority of victims are over fifty-five years old Excellent results have been reported with testosterone

Osteoporosis produces decreased bone density and results from processes that interfere with matrix formation Causative factors include (1) disuse, (2) lack of stress and strain (3) protein deficiency and (4) steroid imbalance

The chief cause of the senile type is underfunctioning of the gonadal hormone producing glands This would explain why the condition is observed in postmenopausal women up to age sixty five When the disorder occurs after this age it is the senile variety although the two types may be indistinguishable A relationship exists between osteoporosis and long-standing eunuchoid males 10 or more years past puberty In these males, the condition is indistinguishable from the senile variety (The opposite situation obtains in alopecia)

The hormone theory is given further support by the observation that the the excretion of calcium and phosphorus in the urine is decreased when estrogens and testosterone are administered The effects are noted within six days and reach a peak within a month The response persists for sixty days after the drug is stopped

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mouth Either 25 mg testosterone propionate is administered intramuscularly every week or 10 mg methyltestosterone orally per day Estrogens and androgens are employed simultaneously to avoid uterine bleeding and virilization

The diet should provide adequate protein but no extra calcium or Vitamin D To prevent edema with androgens sodium chloride is restricted (Potassium should be prescribed) Joints are immobilized no longer than necessary

Pain is relieved in a few months possibly with the growth of uncalcified bone tissue but radiologically visible repair takes much longer

SENILE OSTEOPOROSIS—TREATMENT WITH TESTOSTERONE

When Albright delivered the John Phillips Memorial Lecture on Osteoporosis before the American College of Physicians in 1947 he concluded with the remark I have told you more about osteoporosis than I know In that lecture he defined osteoporosis traced in schematic drawings the normal internal dynamics of the skeleton and the senile disorder produced by decreased production of osteoid by the osteoblasts—osteoporosis—and *still schematically the steroid imbalances and the effects of testosterone* propionate on them and finally the importance of nitrogenous building blocks

He showed why osteoporosis of old age responds to estrogen-androgen therapy The first cause of osteoporosis on a steroidal basis is old age with its atrophy of bone attributable partly to decreased production of anabolic steroids The effect of testosterone propionate is to stimulate protoplasmic anabolism with retention of nitrogen phosphorus potassium and sulfur thus offsetting the atrophy of bone From the stress and strain viewpoint the osteoblast will stop producing if the skeleton is put to rest by immobilization or by paralysis of muscles pulling on the skeleton Stimulation of the osteoblasts by testosterone is achieved either by increasing the anabolism of *protoplasm or by inhibiting the anti-anabolic S hormone or possibly* both The third effect on the osteoblasts is believed to come through raising the serum albumin level thus aiding production of bone matrix

Albright s studies provide a rational basis for the use of testosterone Schoene has reported results of four years observation of 30 cases of senile osteoporosis treated with testosterone propionate Ages of the patients ranged between fifty-five and ninety years All were women except two All had been active until severe crippling back pain and spinal deformity prevented their activity All were believed to be cases of true senile osteoporosis differentiated from postmenopausal osteoporosis of disuse The patients looked old wrinkled gray weather-beaten and washed out Roentgenographic examination confirmed the diagnosis Serum calcium and *phosphorus values were normal*

Testosterone propionate was given intramuscularly 25 mg three times weekly for four weeks then twice weekly for four weeks and finally once a week for four weeks followed by a rest period of four weeks If pain recurred treatment was reinstituted No patient received more than 300 mg a month

Pain disappeared within the first three weeks even though, with few exceptions roentgenograms showed no change in density of the osteoporotic vertebræ In a few cases orthopedic braces were applied to prevent further deformities although pain had already been relieved Rapidity of response appeared not to vary with duration of pain or with the age of the patient No masculinizing effects were observed Two patients showed retention phenomena requiring decrease of dosage, in one case a reawakened sex drive forced discontinuance of therapy In both cases pain relief had already been obtained All patients acquired a sense of well being, looked "years younger" and became more animated The longest period of intermittent therapy was one year, rarely was treatment necessary for longer than three or six months There were no further fractures, three patients were fitted with orthopedic supports Three women had diabetes prior to the osteoporosis Following testosterone therapy the insulin dosage necessary was materially reduced "

Previously, 30 per cent of the patients had been unsuccessfully treated with calcium, vitamins and orthopedic supports

Routine Treatment —One is advised to try the following program 1 Male hormones, (2) female hormones (3) acidogen, (4) calcium by mouth and intravenously (gluconate) (5) Vitamin D (Dicalcium phosphate with Viosterol), (6) local radium or x ray

A satisfactory routine regimen for osteoporosis of the vertebræ is the following

1 Di-Cal-D with chocolate (Abbott Co —10 tablets daily) or dicalcium phosphate with Viosterol or calcium gluconate
2 Acidogen (Abbott Co)
   2 tablets at breakfast
   3 tablets with each meat meal
3 Stilbestrol
   1 mgm at night
4 Testosterone (Oreton-M)
   a 10 mgm tablet daily (never more than 3 weeks out of 4)
5 Vitamin D
6 X-ray therapy or radium
7 Honey
8 Low fat diet
9 Food such as prunes and apricots

Freyberg and Levy advise that postclimacteric persons should be particularly careful to insure generous intake of protein, calcium and phosphorus If roentgenograms reveal significant osteoporosis, treatment should be instituted according to the plan recommended by Reifenstein and Albright using adequate amounts of estrogens or androgens Of the former they recommend doses of 0 5 to 1 mg of diethylstilbestrol orally daily 2 5 to 3 75 mg estrone sulfate or 1 6 to 3 3 mg estradiol benzoate two to three times weekly for two or three weeks then 5 mg weekly for four to six weeks and then rest for one to two weeks Of the male hormone, 10 to 20 mg of testosterone orally and 20 to 25 mg intramuscularly weekly for one to two months, is advised Such a series may be repeated several

times One or two 75 mg pellets of testosterone may be implanted every four months When used, male sex hormones, should be given for at least two or three months Retention of nitrogen and calcium, production of osteoid tissue and calcification of bone result, but benefit is notoriously slow Treatment may be imperative for many months The value of prophylaxis should be emphasized

Prolonged rest quietly in bed, should be avoided wherever possible Dietrick and others have shown that immobility favors the excretion of calcium and causes osteoporosis

A preventive program appears to be indicated regardless of whether or not the patient has menopausal symptoms Estrogen alone has a greater effect on calcium retention than androgen alone, whereas androgen alone has a greater effect on nitrogen retention than estrogen alone However, the combination of the estrogen and the androgen causes a greater amount of retention of calcium than either will produce alone I have had considerable success using tylosterone

Senile and postmenopausal osteoporosis usually respond dramatically to Metandren In early cases, according to Gordon, the minimum effective dose of androgen may be determined by following the urinary Sulkowitch reaction for calcium If the patient avoids milk and cheese the urine will reflect reasonably well a picture of what is going on in the bone On steroidal therapy, the urinary calcium disappears and the urine which formerly gave a milky reaction now remains clear when the reagent is added

Methyltestosterone may be given indefinitely, provided a dose can be established which abolishes symptoms and hypercalcuria without producing masculinization

All bone wherever found is formed through the activities of specialized connective tissue cells the osteoblasts The methods of bone formation are (1) direct or intramembranous (2) endochrondral (3) periosteal The ribs develop by the intramembranous and periosteal methods whereby the bone matrix is formed by the osteoblasts directly within the layer of young connective tissue (Piersol)

There are two chief factors in the absorption of bone one related to the vascular supply and the other to the bone forming cells Persistent vascular dilatation is followed by widening of the canals at the expense of bone, and as the absorption becomes marked the condition of rarefaction or osteoporosis occurs It would appear that in primary vascular resorption the mechanism by which calcium is removed and the canals widened is a physicochemical one Any excessive local production of carbon dioxide tends to cause solution of calcium for the solubility is directly affected by the carbon dioxide tension of the blood and tissue fluid For these reasons only well vascularized living bone can be absorbed quickly Dead bone is absorbed slowly by osteoclasts (Boyd)

There are two requisites for ossification (1) an adequate blood supply and (2) an adequate supply of calcium Emphasis is placed upon the importance of circulatory disturbance in modifying the structure of bone Hyperemia is followed by decalcification and osteoporosis lessened circulation, and loss of blood supply by necrosis Repair of bone is carried out entirely by the osteoblasts which line the deep layer of the periosteum

the endosteum and the haversian canals. The essential function of the periosteum is to supply the outer part of the bone with blood. Removal or separation of the periosteum is apt to be followed by death of this part of the bone (Boyd).

I have formulated an analogy which visualizes *Bricks and Mortar* which require the components of: protein, calcium, Vitamin D, and phosphatase. The *brick layers* are the osteoblasts. The *mechanics* involved includes: (*a*) protected functional use, (*b*) a protein retainer, (*c*) estrogens, and (*d*) androgens. The final phase in the formation of bone may be similar to the "setting" of plaster of Paris or it may be like the crystallization of salt or sugar.

Another analogy visualizes a large furnace in a factory. There are several (1) components, (2) criteria, and (3) variables that must be considered. If one glues two surfaces of substances that ordinarily require *two* hours to agglutinate, and disrupt them at the end of *one* hour, he is doomed to failure. It is possible that some day it will be feasible to spark bone formation by prescribing phosphatase as one does other chemicals, biologicals or drugs.

Estrogens or testosterone are effective in the treatment of osteoporosis. The patient must receive an adequate ration of protein foods.

The clinical improvement very quickly outdistances the *x*-ray visualization or confirmation. The oscillating bed is helpful.

The reader is referred to the writings of Fuller Albright, especially his paper on Osteoporosis. (Annals Internal Medicine, 27, 861, 1947.)

AVITAMINOSIS AND BONE DISORDERS

The most important effects of vitamins upon bone are described by Zanoli. Vitamin A, B Complex, C, D and E all influence bone growth. Nicotinic acid stimulates and accelerates the formation of callus. A subclinical deficiency of riboflavin during pregnancy tends to produce various congenital deformities. It has also been possible to trace some deformities to the lack of pantothenic acid and biotin.

Although an acute deficiency of Vitamin C causes scurvy, a chronic deficiency produces osteophytes and arthropathies which resemble chronic rheumatic disease. Ascorbic acid has an effect upon the formation of callus. Zanoli observed a Vitamin C deficiency in cases of Paget's disease. Vitamin D deficiency produces rickets. It also plays a part in osteomalacia, senile osteoporosis and osteo-dystrophy.

It is possible that the concentric atrophy of bone which is seen in certain muscular diseases is the result of a deficiency in Vitamin E.

An excess of Vitamin A and D is responsible for certain bone disorders. In hyper-vitaminosis A in children, central mid-diaphyseal ossification of the long bones is almost always found. Under experimental conditions when hyper-vitaminosis is carried a stage farther, cortical thinning and fractures occur. Excess of Vitamin D produces decalcification and fractures.

Adrenocortical Response in Operative Procedures Upon the Bones and Joints.—Nicholas and Wilson found that following operation there normally occurs a profound drop in the eosinophil level which is generally followed by a rise to normal or above normal within three of four days

Improvement parallels the rising eosinophil count Persistent eosinopenia beyond the usual stress period is suggestive of developing complications, either of wound healing or of a general nature

Infections cause stress and resultant eosinopenia As infection is overcome, the counts rise toward eosinophilia A rising eosinophil count generally parallels a falling sedimentation rate

Eosinophilia when the clinical course of the patient is unsatisfactory is indicative of adrenal insufficiency and should be checked by the Thorn test A negative result confirms this diagnosis and calls for a trial of cortisone in therapeutic doses

Immobilization in plaster encasements did not produce evidence of stress When plaster jackets were employed for correction of deformity, as in scoliosis the patients showed eosinopenia

Patients with painful conditions such as acute low-back pain exhibited signs of stress

PERI-ARTICULAR CALCIFICATION

Peri articular Ossification —Peri-articular calcifications of ligaments or calcification of articular ligaments in paraplegics is especially common in the hip and knee The author examined some unusual patients at Mayo General Hospital, Galesburg Illinois during the years 1944 and 1945 These patients had several features in common as follows

1 Every one had a spine injury
2 Every one had a cord injury
3 Every one had spastic paraplegia
4 Every one had a neurogenic bladder
5 Some of then had decubiti

The subject of calcification of ligaments comes under the category of heterogeneous calcification The exact mechanics of the deposition of calcium in abnormal tissue involves several factors Calcification can occur without the death of tissue but ossification cannot Kidney stones are common in paraplegics Peri articular depositis of calcium occur around the knee and hip joints in sufficient amount to completely immobilize the joint in spite of the heavy pull of spastic muscles These patients thereby make *for themselves internal long leg braces which enable them to walk on* a tripod base without any active contraction of the leg or thigh muscles

Post-traumatic peri articular calcifications and ossifications present a serious problem They are frequently encountered in military personnel The several types of post traumatic deposits present a multiplicity of roentgenographic appearances Ossifying myositis myositis ossificans progressiva, avulsion sprain fracture and peritendinitis calcarea are some of the terms applied Phemister calls it the Klumpke-Dejerine syndrome

The mechanism of production of vicarious calcification—that is deposition of calcium salts in areas not normally calcified—was given special attention by Howard In certain types of degenerating and necrotic placques, there seems to be a *local* stimulus to lay down a calcifiable matrix Likewise in calcinosis there appears to be some alteration in the fibroblasts

of the subcutaneous, fascial and ligamentous tissues, resulting in the elaboration of an abnormal matrix which calcifies in *normal* extracellular fluid. The vicarious calcification seen when there is hypercalcemia present, however, seems to be differently initiated. Here the excessive concentration of calcium appears to play the important role. One place where vicarious calcification due to hypercalcemia is easy to observe is in the conjunctival tissue of the eye. Howard has seen this phenomenon in patients whose serum calcium was elevated from a variety of diseases—hyperthyroidism, poisoning from vitamin D, sarcoidosis, multiple myeloma, general carcinomatosis, and cancer of the lung without detectable skeletal involvement. A remarkable feature of this hypercalcemic calcification is its reversibility: when the cause of the hypercalcemia can be removed, the lesions have been seen to disappear completely. Whether these deposits are resorbed by enzymatic activity of fibroblasts, as is generally conceded to be true in bone resorption, is not known.

The factors in serum phosphorus homeostasis are obviously of great importance. Phosphorus takes part in many metabolic processes including those of the skeleton. The relation of sex hormones to skeletal metabolism in man is still poorly understood. The spectacular effects of estrogens on the calcium metabolism of birds and certain amphibia appear to have no counterpart in the human. The role of the blood supply in deposition and resorption of skeletal tissues needs further study; the observation of Pearse and Morton that venous ligation speeds fracture healing has never been adequately explained. The mechanism whereby rapid rarefaction of bones occurs when they are put at rest or with severed nerve supply, and the osteolysis resulting from acidosis are not understood.

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become demineralized by hyperparathyroidism or other decalcifying conditions The wearing of excessively high-heeled shoes may cause an exaggeration of the normal lumbar lordosis, which throws abnormal strain on the lumbosacral joint

Spondylolisthesis is frequently seen in orthopedic practice, and is probably due to imperfect fusion of the interarticular portion of the vertebral arch, although in some cases it may be caused by too sudden stress on a vulnerable point—in effect, a fracture I performed the first recorded spinal fusion for acute spondylolisthesis in 1914, with a complete cure

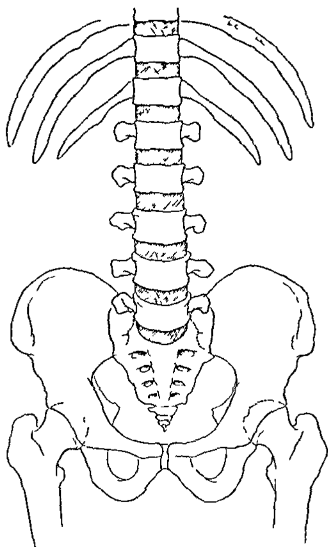


FIG 204 —Diagram of lumbar and pelvic regions and their associated bone structures

When sacralization of a transverse process of the fifth lumbar vertebra exists the opposite side of the vertebra may become depressed flatten the intervertebral disk and narrow the foramen through which passes the fifth lumbar nerve Asymmetry of the articular facets may cause instability of the fifth lumbar vertebra, as may also spina bifida occulta

Extrusion of an intervertebral disk posteriorly into the canal has received an enormous amount of publicity in the medical literature during

CHAPTER 32

LOW-BACK DISORDERS

By Edwin W. Ryerson, M.D., Chicago

LOW-BACK PAIN FROM THE ORTHOPEDIC STANDPOINT

The most frequent causes of low-back pain in children are tuberculosis and osteochondritis. These two conditions present few difficulties in diagnosis. In adults the problems of diagnosis are more complicated

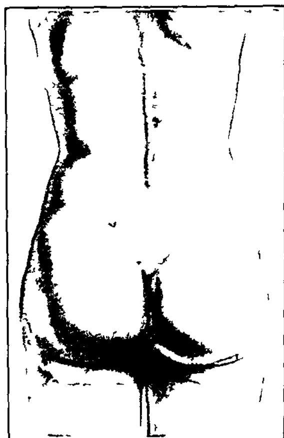


Fig. 203.—Rhomboid of Michaelis. (De Lee and Greenhill: *Textbook of Obstetrics*, courtesy of W. B. Saunders Company.)

because of the large number of conditions which may cause pain low in the back. Arthritis of various types is a frequent offender.

Injuries, such as strains and sprains, may occur in the true joints of the vertebræ, and probably in the sacro-iliac joints. Injuries of moderate severity may cause compression fractures of vertebral bodies which have

become demineralized by hyperparathyroidism or other decalcifying conditions. The wearing of excessively high-heeled shoes may cause an exaggeration of the normal lumbar lordosis, which throws abnormal strain on the lumbosacral joint.

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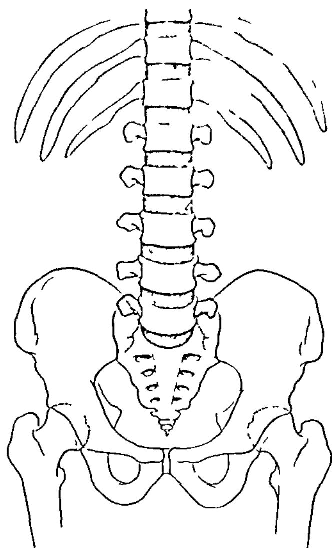


FIG 204.—Diagram of lumbar and pelvic regions and their associated bone structures

When sacralization of a transverse process of the fifth lumbar vertebra exists, the opposite side of the vertebra may become depressed, flatten the intervertebral disk and narrow the foramen through which passes the fifth lumbar nerve. Asymmetry of the articular facets may cause instability of the fifth lumbar vertebra, as may also spina bifida occulta.

Extrusion of an intervertebral disk posteriorly into the canal has received an enormous amount of publicity in the medical literature during

the last few years. It is probable that many disk extrusions have been permanently cured by spinal fusion operations performed under an erroneous diagnosis of instability of the fifth lumbar vertebra. Many of these extrusions cause only temporary symptoms, which subside when the disk recedes into its normal position.

Pantopaque injection may be utilized when the diagnosis is in doubt. Roentgen-ray films must be made during both flexion and extension of the

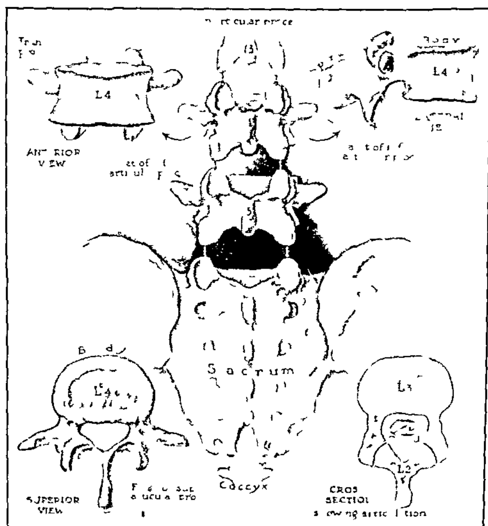


Fig. 205.—The articular facets of the lumbar vertebræ and of the sacrum. (Courtesy of S. H. Camp & Co.)

lumbar spine and also with the patient standing. If the disk recedes when the lumbar spine is flexed forward, a simple spinal fusion operation instead of a laminectomy and disk removal will suffice to cure the symptoms.

Contraction of the tensor fasciæ latæ or of the piriformis muscle undoubtedly can cause sciatic pain and the symptoms may be relieved by operative division of these structures. Fibrositis, myofascitis and fibrous and lipomatous tumors in the sacral and sacro-iliac regions may cause low back pain. New growths, benign and malignant, and blood vessel dilata

tions must also be considered New growths usually cause sensory and motor disturbances which aid in the diagnosis

Disturbances of the sacro iliac joint are not nearly so common as was formerly believed, and can usually be diagnosed by means of Gaenslen's test and by roentgenograms

THE LOW-BACK REGION

The low-back region is of the greatest interest to orthopedic, industrial and military surgeons in their routine athletic, industrial and military practices

It is imperative that the anatomy, physiology and biomechanics must be thoroughly understood in order to interpret the symptoms, signs, pathological and roentgenological changes and to make a correct diagnosis at the earliest moment and institute appropriate treatment A routine and systematic physical examination and expert interpretation of adequate roentgenograms by one familiar with the clinical picture are necessary

The region is divided into lumbar, lumbosacral and sacro-iliac areas The chief types of lesions, from the etiological point of view, are mechanical, traumatic, infectious and neoplastic Arthritis tuberculosis osteomyelitis fracture, dislocation, lumbago, spina bifida, spondylolisthesis and especially spinal cord tumors and lesions of the intervertebral disks are among the most important conditions found in this region

AN ANALYSIS OF MOVEMENT IN THE LOWER LUMBAR SEGMENTS

In 1946 Yount described the mechanics of movement in the lumbar vertebræ He believes that the nucleus pulposis is the chief pivot in the normal spine and that the contributing pivot is the facetal surface Gianturco analyzed movement under normal and abnormal conditions by roentgenological methods He established the existence of a fulcrum located a little posterior to the center of the vertebra and extending over an average of five millimeters In the pathological cases the fulcrum of motion may vary more widely and recede dorsally to the position of the center of the facetal surfaces There was no single pivot In contrast there was a variable pivot over a rather wide range

A MECHANISTIC CONCEPTION OF LOW BACK PAIN

I should like to place before the reader the analogy of what I term a *double U that is one* U superimposed on an inverted U This will help him visualize some aspects of the problem of low-back pain The upper U consists chiefly of erector spinæ, intervertebral disk and ligamentum flavum lesions the lower U includes chiefly the tensor fasciæ latæ the lumbosacral and sacro iliac joints, and the piriformis and coccygeus muscles Each human leg is an "arm" of the theoretical U When the upper and lower U's are superimposed, one has the double U analogy Any procedure that breaks the circuit may give, in certain selected cases,

complete or partial relief These procedures are chiefly injections, liberations, fusions and relief from pressures which follow the operations for protrusion of an intervertebral disk and hypertrophied ligamentum flavum

Anatomy of the Lumbar Spine and Its Variations —Willis discussed the ancestral spinal column from which that of man has evolved, and the manner in which the lower part of the back develops and becomes attached to the vertebral column In early fetal life, the ilia developing in the hind limb buds, approach the vertebral column and become attached to the transverse processes of one or more vertebræ They enlarge, fuse and become the sacrum The points of attachment become the sacro-iliac joints

Willis called attention to congenital anomalies of the lumbosacral and sacro-iliac areas of the skeleton in the syndrome of low-back pain and

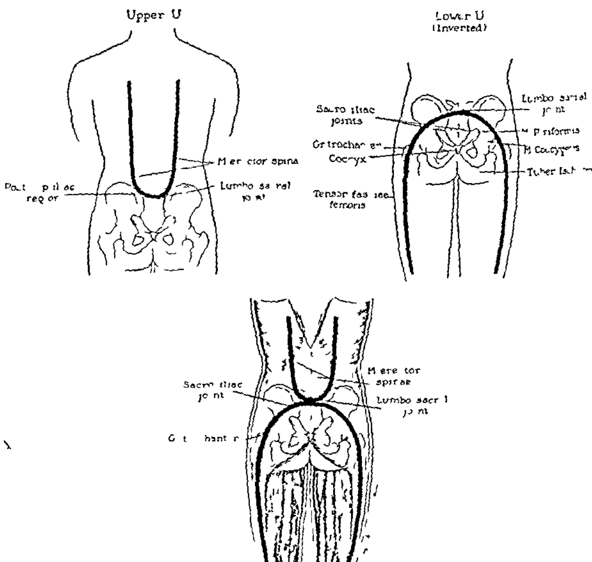


FIG 206 —The mechanistic principles involved in back pelvis and leg lesions Each human leg is an arm of a theoretical U The bends of the U s are at the pelvis The 3 points indicated are lumbosacral right sacro iliac left sacro-iliac joint Any procedure that breaks the circuit may give relief These procedures are 1 tensor fasciotomy 2 erector spinæ liberation 3 lumbosacral fusion 4 sacro-iliac fusion 5 piriformotomy 6 removal of protruded intervertebral disk

sciatica as predisposing or etiological agents or as factors preventing or delaying recovery from these symptoms, after injury. Certain anomalies weaken the anchorage of the spinal column to the pelvis. Others expose the contents of the neural foramina particularly the last presacral nerve roots, to impingement, stress or irritation from postural defects or disease.

Most persons whose backs show anomalies are unsuited to hard manual labor calling for lifting and straining. They are more liable to injury than persons with normal vertebrae.

LUMBOSACRAL ANOMALIES AND POSTURAL VARIATIONS

The clinical importance of lumbosacral anomalies and of postural variations depends in direct proportion upon the extent to which they weaken the part mechanically. The degree to which such anomalies actually predispose to strains and sprains is debatable. Data furnished by Badgley and Hodges indicated little connection. The former, in a study of several hundred patients complaining of backache found these anomalies in 26 per cent. They were present in the same porportion in Willis dissecting room subjects some of whom probably had had low-back pain during their lives.

Willis found that enlarged transverse processes on one or both sides of the last lumbar vertebra may impinge on, articulate or fuse with the lateral mass of the sacrum or articulate with the ilium. There may be variations in conformation of the articular processes, and in their planes of incidence, between the sagittal lumbar and the transverse sacral types. Another manifestation of partial sacralization of a last lumbar vertebra is narrowing of the lumbosacral disk. In anomalous sacralization the vertical diameter of this disk may vary considerably.

Doub described pathological changes accompanying sacralization—fusion of the transverse processes with the top of the sacrum or pseudosacralization in which the transverse processes are large and fan shaped and articulate with the top of the sacrum on either or both sides. These either cause pain in the lower back or after slight injury or strain initiate a chain of chronic symptoms.

A bilaterally defective neural arch weakens the anchorage of the torso to the pelvis at the point where the strain of the upright posture is concentrated. Such an arch can be appreciably separated by injury. Before separation has occurred it is difficult to recognize the defect and it is frequently overlooked. Rarely one finds such an arch in the dissecting room to have been separated or to show spondylolisthesis.

The ligaments and intervertebral joints are of paramount importance in this area. Upon their integrity depend stability, movements, comfort and efficiency. Knowledge of the ligaments is a basic consideration. Brackett emphasized that each case should be studied from all angles, especially keeping in mind that the involvement is not of an individual joint but a group of joints intimately related anatomically and functionally, bearing the same stress, sharing the same strain and frequently yielding as a group rather than individually.

Etiology.—The causes of low-back lesions are congenital defects, infection, trauma, mechanical, postural or static disturbances, weak ligamentous

and muscular support, gastro intestinal disturbances of a mechanical, meta bolic and toxic nature and pelvic and abdominal disturbances Congenital variations include the presence of six or four lumbar vertebræ, spina bifida of the lumbar or sacral vertebræ, long transverse processes of the 5th lumbar vertebra and an unusual position of the sacrum

Goldthwait was the first to scientifically investigate the problem from basic anatomical and mechanical standpoints He pointed out the etio logical rôle which vertebral anomalies, in combination with faulty body posture, play *in the production of sciatic pain* *Infectious causes of low-back* lesions are chiefly arthritis and tuberculosis Infection of the seminal vesicles is important The traumatic causes are strains sprains fractures dislocations and lesions involving the intervertebral disks

Brackett stressed the fact that many different disorders of this area produce similar signs and symptoms The general systemic condition is important With the growing recognition of the importance played by the lumbosacral joint the differential diagnosis of derangements of this joint and of the sacro-iliac joint becomes more difficult

Frequently industrial and other types of low-back pain are due to strains of the joints of the *lower* spine *Disability may be prolonged by* delayed treatment, toxic absorption and faulty posture

Larmon finds two etiologic factors as the basis for low back pain and sciatica (1) Pain may arise in the joints, ligaments and muscles of the lumbosacral region and be referred throughout the distribution of the sciatic nerve (2) Pain may also arise from compression or irritation of the sciatic nerve at its roots This may occur in the spinal canal, in the intervertebral foramina where the nerve roots are in contact with the intervertebral joints, or along the course of the nerve after its exit from the spinal canal

In an experimental study of ten unselected lumbosacral spines, four anatomic and pathologic factors produced compression of the spinal nerves (1) Posterior lipping of the vertebral bodies (2) anomalies of the first sacral body (3) narrowing of the intervertebral foramen due to collapse of a disk, and (4) variations in ligamentous structures adjacent to the fifth lumbar foramen

The fact that fusion of the lumbosacral joint relieves so many low back disorders is good evidence of the anatomical location of so many disturb-ances of this area

Lifting and twisting sprains account for the usual lumbosacral lesions not involving fracture Anatomical variation and postural relaxation also are involved in lesions at the lumbosacral level

Wahren believes the lumbosacral joint is the most important part of the spinal column considered from the standpoint of the etiology of low back pain

The more one has to deal with chronic conditions of back pain the more interest becomes concentrated in the lumbosacral joint It is chiefly in disorders of this joint that surgery is of greatest value

Magnuson finds that the lumbosacral joint must sustain approximately ten times the weight per square inch that is thrust upon the knee joint

Overriding of an articular facet resulting from collapse of a disk causes traction upon the joint capsule which is painful

Low-back Pain With Sciatic Radiation—Low-back pain with sciatic radiation following either a flexion strain or an act of lifting, was described by Haboush as due either to a unilateral rupture of the intertransverse ligament and quadratus lumborum fascia at the level of the 4th intervertebral space or to a rupture of the quadratus lumborum fascia and a fracture of the transverse process of the 5th lumbar vertebra. The tear may extend through the adjoining ligamentous structures and intervertebral fibrocartilage and may produce herniation of a disk. Herniation is dependent upon complete separation of the intervertebral fibrocartilage from both upper and lower surfaces of the adjoining vertebral bodies.

The *genito-urinary causes* of low-back pain are prostatitis, seminal vesiculitis, renal calculus, ureteral calculus, nephroptosis, movable kidney and ureteral kink and hemorrhage. Passive congestion of the prostate and seminal vesicles may cause backache. Backache in pregnant women may be postural, mechanical, traumatic or metabolic. Strain on the supporting muscles and ligaments causes pain. Trauma superimposed upon pregnancy causes a type of low-back pain which is difficult to treat.

Abdominal Tenderness Due to Chronic Strain of the Lumbar Spine and Sacro-iliac Joints.—Midline Abdominal Tenderness.—Carnet found that chronic midline abdominal tenderness is usually due to chronic strain of the vertebral joints, although it may occasionally result from localized or diffuse arthritis, hypersensitive sympathetic nerves or ganglions or the dragging effect of visceroptosis. The more marked the lordosis, the greater the strain on the peri-articular structures.

In making its exit from an intervertebral foramen each intercostal and lumbar nerve passes at a right angle across the edge of a section of the ligamentum subflavum. The stability of a lordotic spine may result in excessive intervertebral movements with undue friction between nerves and their adjacent ligaments.

Hudson called attention to a condition manifested by an intractable abdominal pain with backache in a highly nervous unstable person. When pain persists after removal of all possible intra-abdominal or other lesions an intractable intercostal neuralgia may be present. Paravertebral injection of novocaine is advised as a therapeutic test. Later repeated injections of novocaine alone or novocaine followed by alcohol or resection of the sympathetic ganglion are recommended. These persons are often cast aside as neurotics, fakers or dope addicts and do not receive the sympathy and encouragement that their pitiable state deserves.

Causalgic Backache.—Judovich and Bates called attention to a specific type of back pain which involves the lumbar muscles and especially the quadratus lumborum. A burning pain due to 12th thoracic and 1st lumbar nerve irritation radiates along the 12th rib producing a clinical picture of asymmetrical muscle balance. According to Hudson and colleagues, backache produced by muscle imbalance causes subjective symptoms because the imbalance, together with muscle spasm increases the tension within the quadratus lumborum fascia, producing direct pressure on the 12th thoracic and 1st lumbar nerves. These authors named the syndrome causalgic backache. Patients complain of an upper lumbar backache that is aggravated by rest, awakens them at night and is accompanied by pain

and muscular support, gastro-intestinal disturbances of a mechanical, metabolic and toxic nature and pelvic and abdominal disturbances. Congenital variations include the presence of six or four lumbar vertebræ, spina bifida of the lumbar or sacral vertebræ, long transverse processes of the 5th lumbar vertebra and an unusual position of the sacrum.

Goldthwait was the first to scientifically investigate the problem from basic anatomical and mechanical standpoints. He pointed out the etiological rôle which vertebral anomalies, in combination with faulty body posture play in the production of sciatic pain. Infectious causes of low back lesions are chiefly arthritis and tuberculosis. Infection of the seminal vesicles is important. The traumatic causes are strains, sprains, fractures, dislocations and lesions involving the intervertebral disks.

Brackett stressed the fact that many different disorders of this area produce similar signs and symptoms. The general systemic condition is important. With the growing recognition of the importance played by the lumbosacral joint, the differential diagnosis of derangements of this joint and of the sacro-iliac joint becomes more difficult.

Frequently industrial and other types of low-back pain are due to strains of the joints of the lower spine. Disability may be prolonged by delayed treatment, toxic absorption and faulty posture.

Larmon finds two etiologic factors as the basis for low back pain and sciatica. (1) Pain may arise in the joints, ligaments and muscles of the lumbosacral region and be referred throughout the distribution of the sciatic nerve. *(2) Pain may also arise from compression or irritation of* the sciatic nerve at its roots. This may occur in the spinal canal, in the intervertebral foramina where the nerve roots are in contact with the intervertebral joints or along the course of the nerve after its exit from the spinal canal.

In an experimental study of ten unselected lumbosacral spines, four anatomic and pathologic factors produced compression of the spinal nerves. (1) Posterior lipping of the vertebral bodies, (2) anomalies of the first sacral body, (3) narrowing of the intervertebral foramen due to collapse of a disk, and (4) variations in ligamentous structures adjacent to the fifth lumbar foramen.

The fact that fusion of the lumbosacral joint relieves so many low back disorders is good evidence of the anatomical location of so many disturbances *of this area*.

Lifting and twisting sprains account for the usual lumbosacral lesions not involving fracture. Anatomical variation and postural relaxation also are involved in lesions at the lumbosacral level.

Wahren believes the lumbosacral joint is the most important part of the spinal column, considered from the standpoint of the etiology of low back pain.

The more one has to deal with chronic conditions of back pain, the more interest becomes concentrated in the lumbosacral joint. It is chiefly in disorders of this joint that surgery is of greatest value.

Magnuson finds that the lumbosacral joint must sustain approximately ten times the weight per square inch that is thrust upon the knee joint.

Overriding of an *articular facet resulting from collapse of a* disk causes traction upon the joint capsule, which is painful.

that radiates along the last rib and to the groin Clinical examination reveals increased lumbar lordosis, postural scoliosis, pelvic tilt, abduction and internal rotation of the femur on the side of the low iliac crest, with adduction of the thigh on the side of the high iliac crest There are tenderness and hyperesthesia over the cutaneous distribution of the 12th thoracic and 1st lumbar nerves Treatment includes elevation of the heel of the shoe on the side of the low crest and muscle exercises

The special tests may furnish suspicious, presumptive and pathognomonic evidence of certain disorders Although there is no one test that clinches the diagnosis when considered in combination with other evidence, there are specific tests that make the diagnosis as certain as human knowledge can make it

A "breakdown" of the various tests establishes their values in brief terms One may divide the tests into

A Bone and joint indicators

B Neurological indicators

For example, in the differential diagnosis between lumbosacral and sacro-iliac lesions the *Smith-Petersen test* of flexion of the spine while sitting and standing is simple and reliable

Although acute lesions of nearby structures alter the test by overlap of pain or by tugging action, the *fabere-Patrick test* indicates trouble in or around the hip-joint

The Lewin Snuff Test is a simple diagnostic test for localizing certain spinal lesions

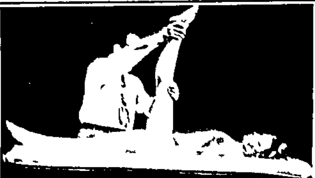
The snuff should be fresh A pinch is placed at the nostrils and the patient is instructed to inhale The sneeze helps to localize the lesion

It can be performed while the patient is standing sitting or lying It not only increases intraspinal pressure but suddenly flexes the head and neck acutely and completely It combines some of the value of the Dejerine Triad, the Neri-bowing test and the Soto-Hall test

The differential diagnosis must consider whether the lesion is in the lower lumbar vertebræ the lumbosacral joint or the right or left sacro-iliac joints Specific lesions must be differentiated, including arthritis Kummell's lesion congenital anomalies with superimposed trauma in the presence of a focus of infection, *intervertebral disk syndrome, intermittent* claudication fracture dislocation, spondylolisthesis calcified ilio-lumbar ligaments and spinal cord tumor

Steindler's Anatomical Differential Diagnostic Data —In cases of low-back pain, Steindler found several patterns of pressure or "trigger points" Steindler reports various syndromes

Sacrospinalis
Lumbosacral
Combined lumbosacrospinalis and sacrospinalis sprain
Combined sacrolumbar and tensor fasciæ strain
Sacrotuberous
Sacrospinalis syndrome in osteo-arthritis
Gluteal

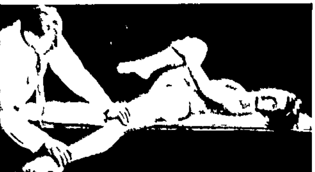
  

Fig. 50. — Supine [illegible] examination of back, hips and legs. (Lewin, Surg. Clin. North America; courtesy of W. B. Saunders Company.)

in herniated disks First and foremost of all, the reflex sciatic pain is purely neuralgic and there are no signs of disturbances of other sensory qualities, no paresthesias, anesthesias or changes in the deep reflexes

Second, the radiating pain follows the local back pain, often only after a later attack, as a sort of cumulative effect of afferent pain impulses, and, third, there is no strict anatomical distribution of the radiation such as is seen in herniated disk cases and the pain does not radiate into the sole or heel of the foot

In none of the cases of purely reflex sciatica, so proved by a positive procaine test, was there paresthesia, anesthesia, loss of reflexes or anatomical extension of radiation to the outer side of the foot or heel The procaine test is an additional valuable test in the differentiation of referred and reflex sciatica

Treatment —Improvement may be obtained in the majority of cases by rest, traction, manipulation, postural exercises, elimination of toxic foci, temporary fixation in plaster-of-Paris, use of a brace or belt or operative exploration or fixation

J H Young finds that attacks of acute lower back pain *without scoliosis* are usually relieved by an epidural injection of procaine These patients have immediate relief from pain, tenderness and limitation of movement Attacks of acute lower back pain associated with *acquired scoliosis* are usually relieved by infiltration with procaine of the sacrospinalis on the convex side followed by traction Patients so treated lose their pain, deformity and limitation of movement in an average of four days After-treatment with a support and exercises is necessary in both types of cases

THE 5TH LUMBAR VERTEBRA

The 5th lumbar vertebra differs from all others in its function, as the end-link of a flexible chain and as the most important shock-absorber of the entire spine It is prevented from slipping forward by the articular processes of the sacrum the iliolumbar ligaments and powerful muscles

It has been likened to the first of a train of cars stopped by a bumper The sacrum and pelvis furnish the immovable bumper so that the 5th lumbar vertebra has to absorb most of the remaining shock

The lumbosacral joint forms the point of contact between flexible and fixed spinal segments The vertical diameter of the body of the 5th lumbar vertebra is greater in front than behind, the transverse processes are short, thick and wedge shaped, the superior articular processes are directed further backward and the inferior articular processes are further forward than those of the other lumbar vertebrae The mechanical inefficiency, due to the obliquity of the antero-posterior axis of the vertebra, is partially compensated for by the strong iliolumbar ligaments and the thickness of the sacro-lumbar intervertebral disk

Anatomical variations which predispose to mechanically imperfect articulations are incomplete neural arch, bilateral laminar defects asymmetrical articular facets and increased obliquity of the articular facets Abnormal mobility in the antero-posterior plane of the neural arch may be demonstrated at the time of operation In some cases the neural arch is entirely separate

Steindler's Procaine Test in the Differential Diagnosis of Sciatic Pain.— There is a possible source of pain phenomenon, namely, that it is of reflex origin. If such a type of reflected sciatic pain is found to exist, it must be carefully differentiated from that kind of referred sciatic pain which is due to direct pressure acting on the posterior roots or on any other point of a peripheral nerve.

In the case of the low-back pain this is facilitated by the fact that many patients show so-called "trigger points," that is, small, strictly localized and distinctive areas of pain on pressure. These are most frequently at the lumbosacral junction, the posterior superior iliac spine, the gluteal insertion at the outer posterior rim of the ilium and the posterior border of the tensor fasciae latae.

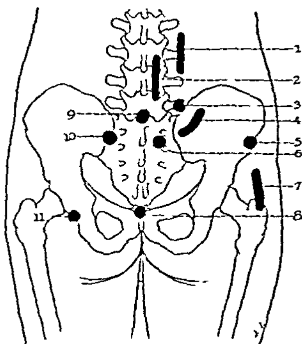


Fig. 208.—Diagram indicating painful or tender areas in low-back lesions. 1, Erector spinae muscle; 2, myofascial syndrome; 3, transversosacral syndrome; 4, gluteal syndrome; 5, superior gluteal nerves; 6, erector spinae syndrome; 7, tensor fasciae latae syndrome; 8, coccygodynia; 9, lumbosacral joint (gluteal syndrome); 10, sacro-iliac syndrome; 11, piriformis muscle. (Redrawn from Steindler, Jour. Am. Med. Assn.)

All these structures as well as all ligamentous, tendinous and aponeurotic structures of the lower part of the back receive their sensory innervation from the posterior primary divisions of the lower lumbar and sacral nerves. The sciatic trunk, on the other hand, composed of the last two lumbar and first three sacral roots, is entirely constituted by the anterior primary divisions of the spinal nerves. There is no communication between the two territories of the anterior and the posterior primary divisions, and any synaptic connection between these two systems must occur not lower than in the spinal ganglions or, more likely, in the spinal cord itself through the lateral horns and the spinothalamic pain-conducting tract.

Clinically, there is a difference between this type of neuralgic sciatic pain and the radiation due to direct posterior root irritation such as exists

[illegible]

[illegible] of the [illegible]



Fig. 211.—Bilateral [illegible] of transverse processes of fifth lumbar vertebra

toms complained of. Flat roentgenograms may indicate that the transverse process is touching the ilium but stereoscopic films usually reveal only overlying shadows. Three other conditions in this region should be recognized in roentgenograms: (1) calcification of the iliolumbar ligaments, (2) sacralization of a 5th lumbar transverse process, (3) lumbarization of the 1st sacral segment.

Elongation of the transverse process may be on the side opposite from the symptoms. Many of the symptoms clear up under treatment for lumbo



Fig 209 —*A* Lines of non union or incomplete union in vertebræ found in the anatomical laboratory *B C D* and *E* Specimens of 5th lumbar anomalies showing four types of weak vertebræ (Redrawn from Willis)

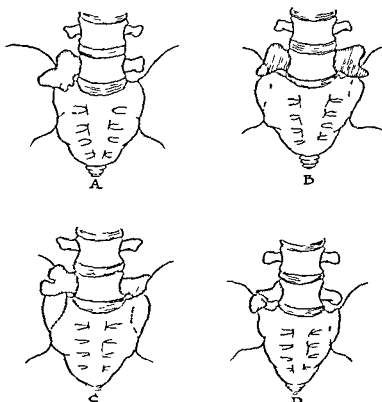


Fig 210 —Sacralization of the 5th lumbar vertebra *A* Unilateral sacralization *B* and *C* bilateral sacralization *D* fracture through sacralized portion of 5th lumbar vertebra (Drawn from roentgenograms)

posterior-superior spine is the most important single criterion Painful forward bending, other motions being free, with painful straight-leg raising, is of almost equal importance A positive response to novocaine injection favors a good prognosis following posterior fasciotomy

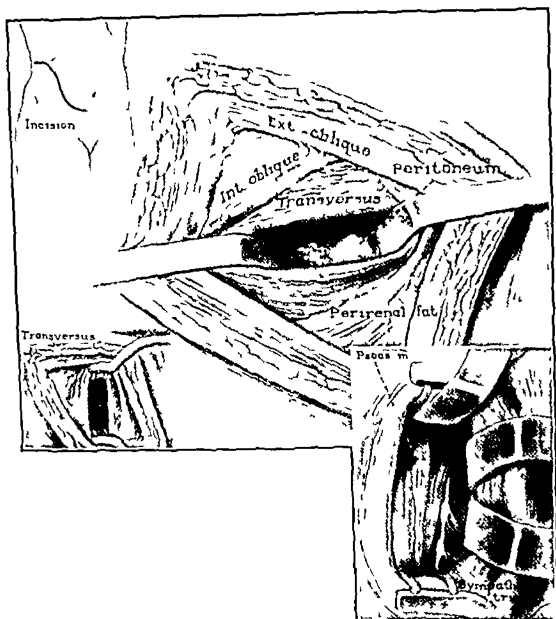


Fig 213 —Anterior flank muscle splitting extraperitoneal approach to the lumbar sympathetic chain (MacCarty courtesy of Postgraduate Medicine)

Ober Operation —Ober found that relief from sciatic pain might be accomplished by releasing the fascial pull exerted through the fascia lata and its attachments to the gluteus maximus muscle The sciatic nerve lies beneath the gluteus maximus where it emerges below the piriformis and any contracture of the fascia must exert muscular pressure on this nerve

Ober concluded that many of the pains attributed to lumbosacral and sacro iliac lesions were due to contraction of one or both iliotibial bands

sacro-iliac strain or arthritis but some require resection of the transverse processes Magnuson Bauman, Bonniot and Putti have described successful operations for this condition

Putti Operation for Resection of Sacralized 5th Lumbar Transverse Process —This operation has been supplanted by exploration for disk lesions

STRAIN OF ILIOLUMBAR LIGAMENTS

The localization of pain and sensitiveness to pressure in the small triangular space formed by the midline of the last two lumbar vertebræ and the posterior portion of the iliac crest is common In many patients, especially those employed in such work as shoveling or running hoisting machinery in which the right arm constantly reaches forward to pull levers, there is a point of great tenderness in this triangle The iliolumbar ligaments aside from acting for lateral stabilization have also a suspensory function, tending to act as a second line of defense in bearing the stress of body weight

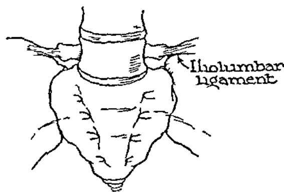


Fig 212 —Calcification of iliolumbar ligaments connecting transverse processes of 5th lumbar vertebra and ilia (Redrawn from roentgenogram)

Calcification of Iliolumbar Ligaments —Doub called attention to the role of ligamentous calcifications in low-back pain The iliolumbar ligaments are triangular with the base of the triangle continuous with the transverse process of the 5th lumbar vertebra and the apex at the insertion of this ligament along the crest of the ilium The iliolumbar ligaments can be demonstrated roentgenographically when of sufficient density (Fig 212)

OPERATIONS ON THE SOFT TISSUES OF THE BACK, PELVIS AND THIGH

Heyman reported cases in which backache had been relieved by a stripping or fasciotomy of the structures attached to the posterior third of the crest of the ilium and the posterior-superior spine The essential point is to recognize that the foci of irritation in many instances are superficial in the ligamentous, fascial muscular or periosteal structures and that these are to be differentiated from bony articular or radicular foci

A summary of the positive findings which suggest the application of posterior fasciotomy indicates that localized tenderness at or near the

posterior-superior spine is the most important single criterion Painful forward bending, other motions being free, with painful straight-leg raising, is of almost equal importance A positive response to novocaine injection favors a good prognosis following posterior fasciotomy

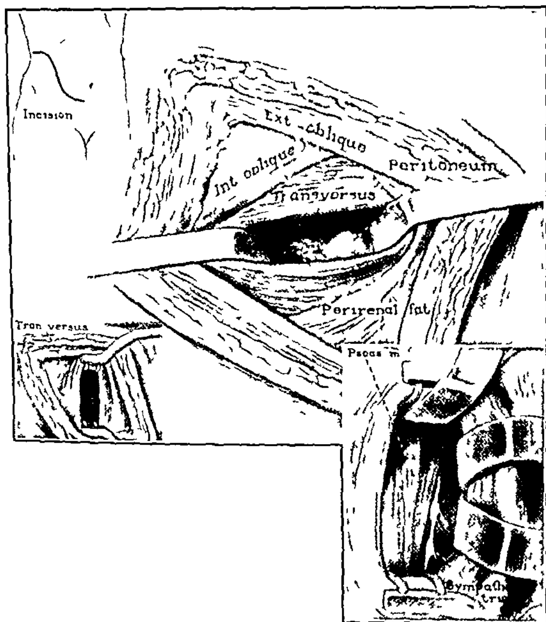
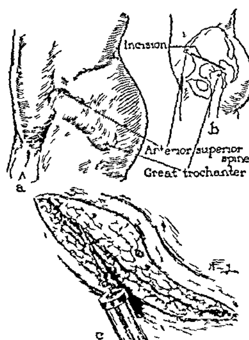


FIG 213—Anterior flank muscle-splitting extraperitoneal approach to the lumbar sympathetic chain (MacCarty courtesy of Postgraduate Medicine)

Ober Operation —Ober found that relief from sciatic pain might be accomplished by releasing the fascial pull exerted through the fascia lata and its attachments to the gluteus maximus muscle The sciatic nerve lies beneath the gluteus maximus where it emerges below the piriformis and any contracture of the fascia must exert muscular pressure on the nerve Ober concluded that many of the pains attributed to lumbosacral and sacro-iliac lesions were due to contraction of one or both iliotibial bands

Patients who have sciatic pain with a contracted iliotibial band get relief when the band is divided above the trochanter, thereby relieving the tension of the gluteus maximus muscle, where it inserts into the fascia and into the tensor fasciæ femoris There is a triangular pull here which Ober considers is the key to the situation He claims it has been demonstrated that fascial contractures occur at the junction of thigh and pelvis There is a definite relation between muscle and fascial contractures of the leg and the mechanics of the whole spine There is also a definite relation between fascial contractures and some cases of sciatic pain

Ober gave his indications for the operative relief of fascial contractures as follows (1) meralgia paræsthetica, (2) sciatica of long standing, (3) sciatica plus lame back, (4) chronic lame back, (5) unsuccessful lumbo sacral fusion, and (6) failure after fasciotomy on the opposite leg



FIGS 214 to 217 —THE OBER OPERATION

FIG 214 —a Line of infiltration of novocaine in the skin b line of incision c infiltration of subcutaneous tissue and fascia lata with novocaine (Cave Surg Clin North America)

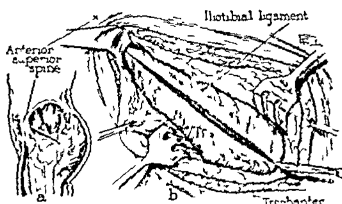


FIG 215 —a Showing line of incision through deeper structures b division of the fascia lata and the iliotibial band (Cave Surg Clin North America)

Operative Technic.—The operation is performed as follows: An oblique incision, 4 to 6 inches long, is made from the lower edge of the anterior superior spine downward and backward, to a point just above the level of the greater trochanter and just posterior to it. The skin and subcutaneous fascia are separated by clean dissection above, below and posteriorly until a strip about 2 inches wide has been dissected well back over the anterior surface of the gluteus maximus muscle. The fascia is now divided from the anterior-superior spine well back over this muscle. The fascia gaps at the incision, and the flaps are dissected off the muscles for about 1 inch on each side. All intermuscular septums in this region are divided. If there is a positive Ely sign, the fascia surrounding the sartorius muscle is also divided. All loose tags of fascial tissue must be removed. As soon as the section is completed, there is a marked separation of the cut surfaces. The fascia is further separated by blunt dissection until there is a gap of 2 inches. In some instances, pathological examination of the iliotibial band has shown chronic inflammation.

Patients who have sciatica with a contracted iliotibial band get relief when the iliotibial band is divided. The band must be divided above the trochanter in order to relieve the tension of the gluteus maximus where it inserts into the fascia and also the tensor fascia. Some of the cases take from six to eight weeks to clear up, but most patients get some relief within twenty-four hours.

I have performed the operation entirely subcutaneously, many times with routine success.

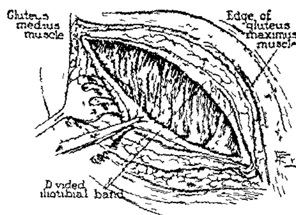


Fig. 216.—Iliotibial band has been divided and retracted upward and downward. This drawing shows the incision in the iliotibial band and fascia lata to extend well down beyond the edge of the gluteus maximus muscle. (Cave: Surg. Clin. North America.)

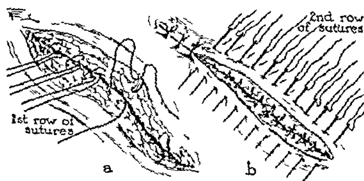
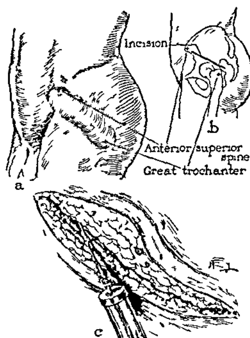


Fig. 217.—*a*, Suturing of the subcutaneous tissue with knots tied deep rather than superficial. *b*, suturing of skin. (Cave: Surg. Clin. North America.)

Patients who have sciatic pain with a contracted iliotibial band get relief when the band is divided above the trochanter, thereby relieving the tension of the gluteus maximus muscle, where it inserts into the fascia and into the tensor fasciæ femoris There is a triangular pull here which Ober considers is the key to the situation He claims it has been demonstrated that fascial contractures occur at the junction of thigh and pelvis There is a definite relation between muscle and fascial contractures of the leg and the mechanics of the whole spine There is also a definite relation between fascial contractures and some cases of sciatic pain

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Figs 214 to 217 —The Ober Operation

Fig 214 —*a* Line of infiltration of novocaine in the skin *b* line of incision *c* infiltration of subcutaneous tissue and fascia lata with novocaine (Cave Surg Clin North America)

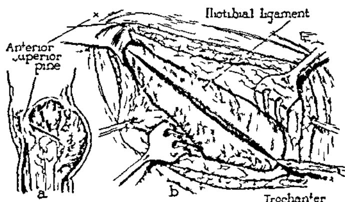


Fig 215 —*a* Showing line of incision through deeper structures *b* division of the fascia lata and the iliotibial band (Cave Surg Clin North America)

The pathological changes depend on the cause of the lesion. There are narrowing of the intervertebral spaces and irritation of the psoas and superior gluteal muscles. Attacks may be brought on by some sudden movement or strain, suggesting "nipping" of villous articular surfaces.

Changes within the lumbosacral disk were estimated by Williams to cause low-back pain in more than 90 per cent of cases. A narrowing or a complete loss of the intervertebral disk between the 5th lumbar and the 1st sacral vertebra was noted in the majority of his patients suffering from sciatic irritation.

Symptoms.—The most important lumbosacral symptom is pain, which is referred to the hip, gluteal region, thigh, calf and heel. Slight and moderately severe injuries are usually neglected, and arthritis may be superimposed.

Roentgen-ray Findings.—Narrowing of the intervertebral joint space is not so important in the interpretation of roentgenograms as an over-riding of the facet articulations because further settling of the disk is frequently prevented by contact of bony structures. Frequently the 1st sacral facets lodge in the inferior vertebral notches before an appreciable narrowing of the disk is apparent. Under such conditions they become weight-bearing structures and produce wedging and irritation of the inferior vertebral notches of the 5th lumbar vertebra, as well as sclerosis of the superior margins of the 1st sacral facets themselves. In an antero-posterior film this sclerotic change presents an irregular line at the junction of the lamina and the inferior articular facet of the 5th lumbar vertebra which may be misinterpreted as a fracture. In addition, the bone irritation in the inferior vertebral notch may cause spur formation. All films intended to reveal facet disturbances should be stereoscopic.

Strain at the lumbosacral joint, according to von Lackum, is always shearing regardless of position. The shape of the 1st sacral segment is of primary importance in reducing this strain because of its bearing on the angles. Backache may be caused by an increased lumbosacral angle, which predisposes to increased strain. Backache following prolonged bed rest or acute illness may be the result of strain. Anatomical deformities in this region predispose to disability and deformity.

Brackett stressed two effects of the horizontally placed sacrum: (1) the anterior shearing force which in consequence of the obliquity of the sacral segment affords resistance to superincumbent weight with a tendency to yield to the forward movement of the 5th lumbar vertebra, toward spondylolisthesis; (2) the twisting leverage force on the sacro-iliac joint resulting from the forward and downward rotating motion of the upper end of the sacrum when the superincumbent weight falls forward at this joint instead of passing through it.

Willis considered that asymmetrical sacralization and defective lumbosacral articulations provide points of greater vulnerability to stress and strain with a definite susceptibility to muscle and ligament injury. The lumbosacral region is inherently weak, because the spine developed for quadrupedal function with a support under either end, has been forced to accommodate itself to a right angle turn and balance in the upright position, thereby acquiring mechanical imperfection and points of exaggerated stress.

CHAPTER 33

LUMBOSACRAL JOINT DISORDERS

Anatomy and Biomechanics.—The chief ligaments of the lumbosacral articulation are long and slender, composed of non-elastic fibrous tissue. The two lumbosacral ligaments arise from the lower front part of the 5th transverse process and are attached below to the lateral surface of the top of the sacrum. The two iliolumbar ligaments arise from the tips of the 5th transverse process and are attached to the crests of the ilia.

The sacrum is slung between the ilia and supported by strong ligamentous and muscle attachments. Anteriorly the short transverse sacro-iliac ligaments bind the bones together. Posteriorly the sacrum hangs on tough fibrous bands extending between the rough iliac tuberosities and the back of the sacrum. *Distally, the sacrosciatic ligaments help to stabilize the* articulation.

Steindler emphasized that the pelvis motivates the spine rather than the reverse.

Calve and Goldthwait have shown that 50 per cent or more of the movement of the trunk below the thoracic region occurs at the lumbosacral articulation. Therefore these four long, slender ligaments, lying around a structurally weak joint, are in danger when protection is lost even for a moment. This occurs as the muscle relaxes preparatory to a strong muscle contraction when the patient is usually in the flexed, or the twisted attitude positions which inherently predispose to ligamentous strain.

Etiological Factors.—The causes of lumbosacral disturbances are congenital variations, traumatic factors, postural defects, infectious conditions, arthritis, disk lesions and neoplasms. Deformity may cause faulty posture or gait, obliteration, exaggeration or reversal of the normal antero-posterior spinal curvature, lateral curvature, and limitation of movements.

Usually acute and frequently chronic backache in young adults follow repeated sprains of the lumbosacral ligaments, from laborious work. Athletics or the assumption of an awkward posture during such muscular efforts such as lifting and pushing predispose to backache.

According to Putti, pathological changes occur in the intervertebral foramen between the 5th lumbar and the 1st sacral vertebrae, wherein lies the 5th root of the lumbosacral plexus, the principal constituent of the sciatic nerve. If the transverse process of the 5th lumbar vertebrae is wider and deeper *than normal, as in sacralization, the lumen of the canal* is narrowed and lengthened and the 5th root may be irritated or compressed as it runs through the canal, causing pain. These anomalies may alter the shape of the intervertebral foramen, reduce its capacity and by altering the mechanics of the spinal column, induce a localized arthritis, which in itself may irritate the nerve trunk. The same effect may be produced by an inflammatory process in the vertebral articulations.

Anatomical variations in the lumbosacral region are numerous and important The lumbosacral angle varies within wide limits in normal persons, being much less in infants than in adults The angle at which the lumbar spine articulates with the sacrum varies from 90 to 140 degrees The shearing force exerted at this junction may be minimized by a development of the 1st sacral body to meet it in the absence of which there is definite strain and pain to those engaged in laborious occupations

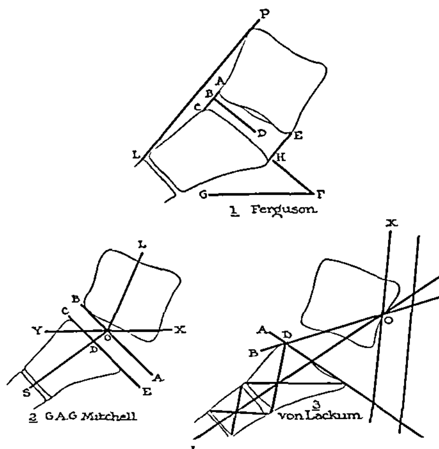


Fig 219 — Some methods of measuring the lumbosacral angle

1 (Ferguson)—*EH* is the anterior line parallel to *LP* *BD* is the line which bisects the plane of the lumbosacral joint *AC* is the line by which displacement is judged It is at a right angle to *BD* *HF* is the plane of the 1st sacral surface *GF* is the horizontal The angle *HFG* is the lumbosacral angle

2 (G A G Mitchell)—*LO* and *SO* are lines bisecting the last lumbar and 1st sacral vertebræ the line *AOB* is parallel to the plane of the upper surface of the 1st sacral vertebra and *XY* is a horizontal line The angle *LOS* is the lumbosacral angle and the angle *YOB* measures the inclination to the horizontal of the upper surface of the 1st sacral vertebra

3 (von Lackum)—The angle *XOY* is the lumbosacral angle The angle *ADB* is that made by the superior surface of the sacrum from which the shearing strain is determined

According to Dickson the lumbosacral articulation inclines downward and forward about 42 5 degrees when the person is standing erect Were it not for the articular facets of the sacrum into which the lower articular processes of the 5th lumbar vertebra fit and the supporting ligaments, the lumbar vertebrae would slide forward on the sacrum The articular facets in the lumbar region face practically inward and outward with a slight convergence toward the front which blocks any slipping forward of the

von Lackum called the lumbosacral joint unstable because (1) it is at the juncture of a mobile and an immobile part of the spine, (2) it lacks the usual means of joint stabilization in consequence of a developmental structure designed for the all-fours position, (3) it is the site of a rotating often asymmetrical action, (4) it is the focal point of tremendous shearing strain.

"Unstable lumbosacral joint" was described by Ferguson as a clinical entity which includes any arrangement of bony parts that is not adequate for support, without undue stress or strain on the adjacent muscles and ligaments.

Haggard believes that lumbosacral anomalies produce symptoms only through faulty mechanics. As long as the muscles and ligaments are of sufficient strength and tone to enable the person to continue his activities

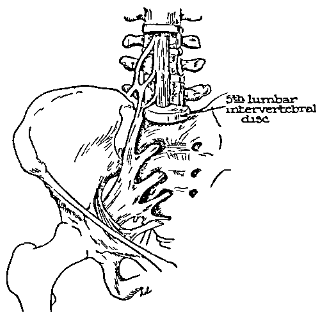


Fig 218.—Sketch showing relations of the lumbosacral plexus especially the proximity of the 4th and 5th lumbar nerve roots to the 5th lumbar intervertebral disk and to the sacroiliac joint. (After Danforth and Wilson Jour Bone and Joint Surg.)

without fatigue, there are no symptoms, that is the patient is "compensated." Decompensation and back pain result from failure of the muscles and ligaments to support the lumbosacral area.

Relation of the Lumbosacral Joint to the Lumbosacral Plexus.—The lumbosacral plexus is made up of branches of the 4th and 5th lumbar nerve roots in addition to the sacral roots. It supplies sensation to the buttocks and to the anterior and posterior aspects of the thigh. Emphasis has been placed on the ligamentous "guy rope" and the relation of the bony structures to one another, whereas undeserved importance has been given to the bony abnormalities. The sacrospinalis muscle with its attachments to the sacrum and ilium and the glutei with their origins from both the sacrum and ilium tend to support rather than separate the joint. The sacrospinalis muscle receives some injury in most lumbar strains and may be the only structure affected.

Anatomical variations in the lumbosacral region are numerous and important The lumbosacral angle varies within wide limits in normal persons, being much less in infants than in adults The angle at which the lumbar spine articulates with the sacrum varies from 90 to 140 degrees The shearing force exerted at this junction may be minimized by a development of the 1st sacral body to meet it in the absence of which there is definite strain and pain to those engaged in laborious occupations

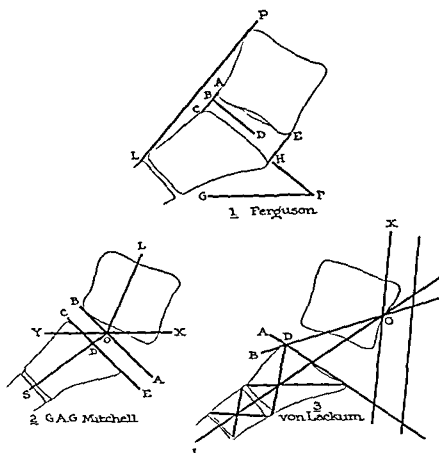


FIG 213 – Some methods of measuring the lumbosacral angle

1 (Ferguson)—*EH* is the anterior line parallel to *IP* *BD* is the line which bisects the plane of the lumbosacral joint *AC* is the line by which displacement is judged It is at a right angle to *BD* *HF* is the plane of the 1st sacral surface *GF* is the horizontal The angle *HFG* is the lumbosacral angle

2 (G A G Mitchell)—*LO* and *SO* are lines bisecting the last lumbar and 1st sacral vertebræ the line *AOB* is parallel to the plane of the upper surface of the 1st sacral vertebra and *XY* is a horizontal line The angle *LOS* is the lumbosacral angle and the angle *YOB* measures the inclination to the horizontal of the upper surface of the 1st sacral vertebra

3 (von Lackum)—The angle *XOY* is the lumbosacral angle The angle *ADB* is that made by the superior surface of the sacrum from which the shearing strain is determined

According to Dickson the lumbosacral articulation inclines downward and forward about 42 5 degrees when the person is standing erect Were it not for the articular facets of the sacrum into which the lower articular processes of the 5th lumbar vertebra fit, and the supporting ligaments the lumbar vertebræ would slide forward on the sacrum The articular facets in the lumbar region face practically inward and outward with a slight convergence toward the front which blocks any slipping forward of the

vertebra above, on the vertebra below The ligaments, particularly the iliolumbar, which pass from the body and transverse processes of the 5th lumbar to the iliac crests, afford considerable support but would soon become stretched and lose their supporting character if the major portion of the strain were not taken by these bony articular processes

The conditions which most commonly cause weakness of the lumbosacral joint may be placed in two groups (1) increased sacral inclination (2) such congenital anomalies and deficiencies as abnormalities of the articular processes of the 5th lumbar vertebra and sacrum, spina bifida occulta spinal clefts, enlarged transverse processes, sacralized transverse processes and enlarged spinous processes

The body of the 5th lumbar and of the lumbosacral intervertebral disk is thicker anteriorly than posteriorly, as a result of which the weight of the trunk exerts a shearing strain at this joint and tends to diminish the angle However according to Willis, a thick disk is in itself no proof of a destructive or pathological lesion, particularly when such a disk is associated with enlarged transverse processes or other evidence of anomalous sacralization

The articular facets of the lumbosacral joints show great variation in their shape and in the plane of the articular surfaces The superior articular facets in the majority of sacrums are slightly crescentic, facing backward and slightly inward If the greater part of the facet faces backward, no indication of the condition of the surface of the joint can be obtained from a roentgenogram but if the greater part faces inward the joint surfaces with a narrow space between them can be seen on the film and any irregularity of the surface detected In some cases one facet faces backward and the other inward a condition which Putti described as an "anomaly of articular tropism

The Roentgen Appearance of the Normal Lumbosacral Region —The radiographic appearance of the lumbosacral region varies according to the location of the roentgen-ray tube in relation to the last lumbar vertebra Kleinberg stressed the fact that if the tube is directly over the lumbar vertebræ so that its central rays pass through the lumbosacral junction the lumbar vertebræ in an antero-posterior view appear as quadrilateral shadows The last lumbar is distinctly visible and is larger than or at least as large as the other vertebræ The intervertebral spaces above and below the last lumbar measure at least ¼ inch vertically Laterally the intervertebral spaces are bridged by the articular processes Each lumbar vertebra is distinctly outlined and the 5th lumbar is separated from the sacrum by an appreciable interval

One must look for evidence of congenital defects infection and trauma likewise for atrophy hypertrophy destruction of bone fracture and dislocation A lateral film is required and stereoscopic and oblique projections are often advisable

Between lumbosacral and sacro-iliac strains differentiation is based on localization and radiation of pain Diagnosis depends on whether pain in the back accompanies compression of the iliac crests (in sacro iliac involvement) and straight leg raising between 180 and 140 degrees (this must occur before 135 degrees to be of much value) Anatomically separate

points of local tenderness are indicative the Gaenslen and other tests must be interpreted and roentgen study should be confirmatory

Diagnosis between sacro-iliac and lumbosacral lesions is important in determining operative procedures Wentworth found the flat lumbar spine common with sacro-iliac subluxation and that pain is referred down the back of the leg in sacro-iliac lesions, but down the front of the thigh in lumbosacral conditions

Smith-Petersen stressed the fact that when a patient with sacro-iliac strain is seated with the knees in semiflexion so that the hamstring muscles are relaxed he could bend forward with ease where as forward flexion while standing was limited by the tension of the hamstring muscles which held the pelvis fixed When the lumbosacral joint is involved there is no difference in the spinal movement during sitting or standing since the lumbosacral region is held rigid, and forward flexion occurs at the hips With sacro-iliac lesions the forward bending takes place in the lumbar spine Anatomical variations of the planes of the lumbar articulations as well as impingement of transverse processes, predisposes to low-back strain and sprain Increase in the horizontal position of the sacrum and increased lumbar lordosis predispose to lower lumbar and lumbosacral sprain

In either sacro-iliac or lumbosacral sprain, radiating pains may follow the distribution of the sciatic nerve, the area supplied by the nerves of the lumbar plexus or the course of the gluteal nerves

Uncomplicated lumbosacral sprain does not produce a body list or a limp, as a rule

Altered reflexes, muscle atrophies and paralyses localized clonic contractions, trophic changes, areas of decreased or altered tactile sensibility and hyperalgesia are important in neuritis, perineuritis radiculitis and nerve injury, but not in bone and joint lesions Areas of localized tenderness are of great diagnostic value In most injuries both the lumbosacral and sacro-iliac ligaments are involved

Prognosis depends on causation and the amount of elapsed time between the onset of the symptoms and the institution of treatment

Treatment —Every patient should be given conservative treatment before radical measures are considered Under a thorough conservative program more than 90 per cent of the patients will be relieved Spinal operations should not be employed until a thorough conservative program has overcome fixed lumbosacral lordosis and lengthened short fascia and muscles of the anterior and lateral aspects of the thigh The latter may require resection, as described by Ober If this is not done the pain just above a graft or at the sacro-iliac joints, due to downward pull on the front of the pelvis may either persist or make its appearance after operation on the lumbosacral spine A well placed graft and in some cases a facetectomy are safeguards against post-operative symptoms

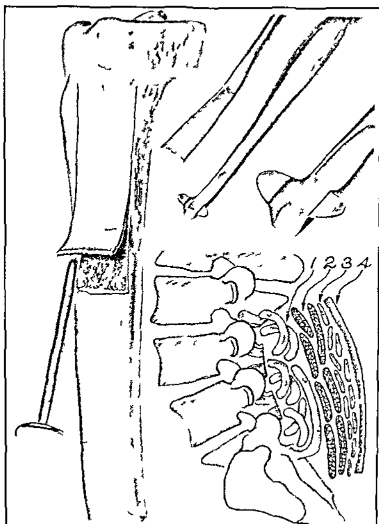
Non-operative treatment consists of recumbency in bed, the application of support (adhesive strapping and belts of various types) and physical therapeutic measures When backache at the lumbosacral junction is uncontrollable by such measures a fusion operation is recommended For large impinging transverse processes of the 5th lumbar, relief may be obtained by either resection or fusion The Hibbs, the Albee and the

Hibbs operation with additional osteoperiosteal grafts, described by Delageniere and Lewin, are the usual procedures

The operation for ankylosing the 5th lumbar vertebra to the sacrum is performed in Dickson's clinic after the method of Hibbs, in addition an osteoperiosteal graft from the tibia is placed on each side between the laminæ of the upper sacral segment of the 5th lumbar vertebra Such grafts add to the certainty of ankylosis

INTERNAL FIXATION FOR LUMBOSACRAL FUSION

Following the usual exposure, King cauterizes the lumbosacral joint and the remaining cartilage cells by means of a flat flexible, electro cautery tip



Figs 220 221 and 222 —Lumbosacral fusion for relief of low back pain (Lee courtesy of *J Bone and Joint Surg*)

Fig 220 —Spine fusion showing *Left* Removal of osteoperiosteal grafts from the tibia *Upper Right* Special instruments used for turning up grafts from the laminæ and sacrum and obtaining cortical chips of bone from the tibia *Lower Right* The various layers of grafts in place (1) The grafts turned up from the laminæ and sacrum (2) The cut up spinous processes (3) The cortical slivers of bone obtained from the tibia (4) The broad grafts obtained from the tibia

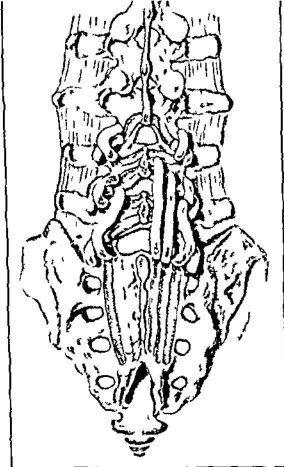


FIG 221 —Spine fusion showing heavy chip grafts turned up and down from each lamina and overlapped Grafts are also turned up from the sacrum (Lee courtesy of J Bone and Joint Surg)

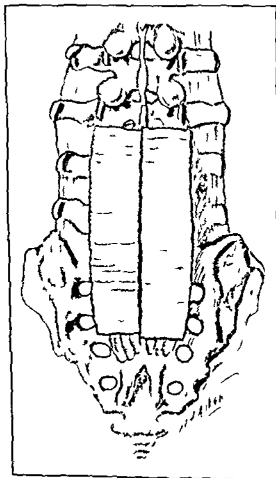


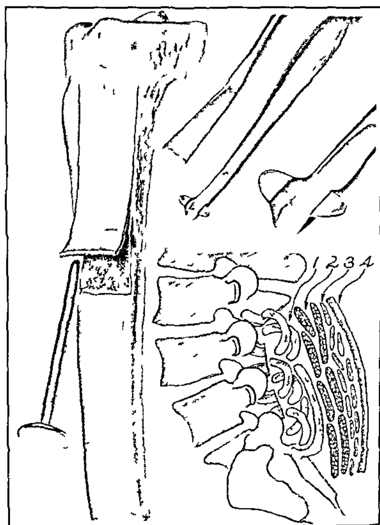
FIG 222 —Spine fusion showing broad tibial graft in place (Lee courtesy of J Bone and Joint Surg)

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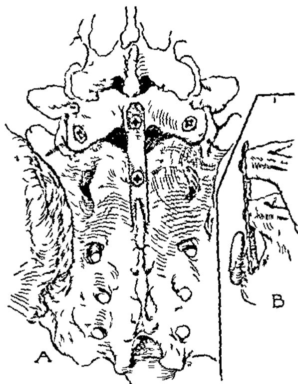


Fig. 224.—*A* posterior view of lumbo-sacral joint showing screws through lateral articulations and tibial graft screwed to spinous processes. Multiple chip grafts are not shown. *B* lateral view showing tibial graft. (King, courtesy of J. Bone and Joint Surg.)

Fig. 225.—Illustrates use of notched Bennett retractor for exposure of lateral articulations and special osteotome for removal of articular cartilages. (King, courtesy of J. Bone and Joint Surg.)

A No. 31 drill is used to make a screw hole and a $\frac{3}{4}$-inch vitallium screw is inserted through the inferior articular facet, the articular space, the sacral facet and body of the sacrum. If the screws are inserted parallel to the inferior edge of the 5th lumbar lamina, immediate completely stable fixation is secured. Multiple bone chips are elevated and distributed in the usual way. In those cases in which the sacral spinous processes are well developed immobilization is further reinforced by applying a heavy tibial graft to the spinous processes and fixing it there with screws. No support is necessary and the patient becomes ambulatory within a few weeks.

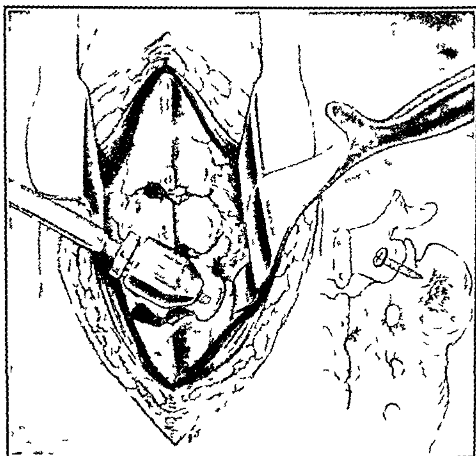


Fig. 223.—Showing insertion of drill point and screw. (King, courtesy of J. Bone and Joint Surg.)

The Flexion Treatment for Low-back Pain.—Breck and Basom devised an operative procedure in which a block of bone from the tibia or ilium is snugly mortised between the spinous processes of the 5th lumbar vertebra and the sacrum with this joint flexed and these spinous processes separated. It also gives internal fixation to the routine spine-fusion grafts. Following this operation, the patient is placed in a body cast extending from the upper thoracic spine to the knees. Both thighs are included with the hips flexed about 35 degrees, and with the lumbar spine maintained in flexion.

CHAPTER 34

SPONDYLOLISTHESIS

SPONDYLOLISTHESIS means slipping of a vertebra This causes signs and symptoms of "vertebral insufficiency " a characteristic shape and appearance of the back and trunk and a definite roentgen picture The condition was described by Herbiniaux in 1782 but the modern concept dates from the work of Neugebauer in 1884 The term was coined by Killian, who attributed the condition to a gradual slipping of a vertebra In reality only the body and anterior portion of the arch slip, while the posterior portion of the arch and spinous process remain in their normal positions In Wales it is called ' miner s back

Localization —Most commonly the lesion is at the lumbosacral joint, less commonly, at the junctions of the 4th and 5th and 3d and 4th lumbar vertebræ It may occur in the cervical region The slipping may be forward or backward Meyerding reported 62 per cent in males, among more than 250 cases There were only three instances of backward displacement of the vertebræ, one of slipping of the 2d lumbar vertebra on the 3d and two of slipping of the 3d on the 4th

Forward displacement of the 5th lumbar vertebra on the sacrum may develop early or late in life When due to a congenital anomaly, this defect is a true separation of the neural arch from the rest of the body, allowing the 5th lumbar vertebra to slide forward When fusion between the body and the pedicle fails to take place an articulation appears at this point, and the condition known as prespondylolisthesis exists

The causes may be hereditary congenital traumatic postural infectious or idiopathic The anomaly is primarily congenital but the actual displacement is due to superimposed trauma No instance of true congenital spondylolisthesis (that is of a newborn child with a demonstrable displacement) has been reported

Spondylolisthesis implies a pseudarthrosis at the junction of the neural arch and vertebral body This produces a pre-spondylolisthesis, which becomes a true spondylolisthesis by the action of trauma as in diving

The development of the lesion is contingent on a basic separation of the vertebral neural arch In his classical studies Willis found the defect in 5 19 per cent of 1520 examinations

Etiological Factors —Chiari inclined to the theory of defective ossification as the prime factor Meyer-Burgdorff said that in most cases the *condition* is acquired The fissure at the isthmus of the vertebral arch is the result of a chronic bone change exaggerated by the lordosis It may follow fracture of the lower thoracic or upper lumbar vertebræ He studied 40 true and 143 suspected cases

According to Steindler, trauma is a secondary, superinducing factor The greatest aid in the study of the problem has been improved roentgenray technic and actual observation of the local condition during operations

CAMPTOCORMIA (BENT BACK OR FLEXED BACK)

The term camptocormia was originally used by Souques Hurst reported a similar condition under the name of "bent-back " Saliba called it autalgic spinal distortion Rosanoff-Saloff divided his patients according to whether they had been wounded or not In the second group were patients who had been victims of shallow explosions, being thrown to the ground by the force of the explosion and suffering thoracolumbar injury Lumbar pain was a prominent symptom, gradually subsiding after many days in bed On getting up, the patients found that they could not stand erect, even though all pain had disappeared

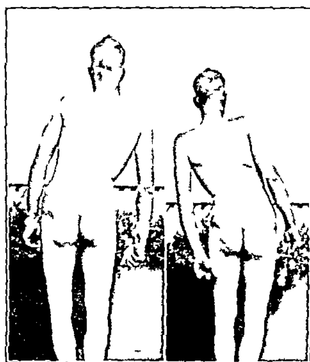


FIG 226 —Reversible camptocormia brought on by injury cured by lumbosacral fusion Undoubtedly a midline disk—a floater

Hall reported a case of camptocormia evidently purely functional quoting Rosanoff-Saloff who stated that all of his 16 patients were more or less neuropathic All types of spinal deformity have been reported lordosis, kyphosis and scoliosis Hurst called the disease purely functional and advised psychotherapy Electricity is employed as a means of suggestion, as are hypnotism, persuasion and re-education Hurst's method of treatment is to put the patient on a board in a horizontal position with his feet firmly fixed against a right angled footboard The patient is then gradually raised to the erect position and in that way is impressed that his body can be placed in the erect position The patient should be treated in a neuropsychiatric hospital, under the strictest discipline

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According to Steindler trauma is a secondary superinducing factor The greatest aid in the study of the problem has been improved roentgenray technic and actual observation of the local condition during operations

The fundamental lesion which precedes and results in spondylolisthesis is an interruption in the continuity of the neural arch Such defects are found with remarkable constancy in the narrow isthmic or interarticular portion of the neural bow at the junction of pedicles and laminæ Usually the defect is bilateral with the body, pedicles and superior articular processes separated from the laminæ spine and inferior articular processes As a consequence the security of the spinal column is diminished through interference with the solidity of its bony anchorage The vertebra is in a sling instead of a block of bone

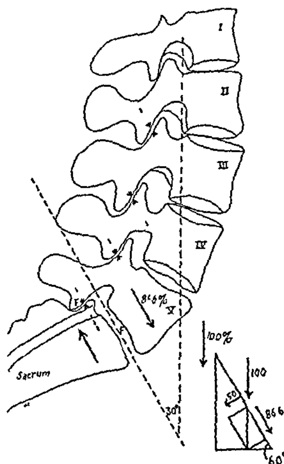


Fig 227 —Diagram showing forces acting on the isthmus of last lumbar vertebra (Chandler Surg Gynec and Obst)

Thirty-eight per cent of Meyerding's series of patients ascribed their trouble to trauma In all of Henry's cases the same causative mechanism was described i e landing on the buttocks in the sitting position with the spine erect In 12 of Chandler's 18 cases the onset of symptoms was abrupt and in all but one was associated with a shearing strain

In pseudospondylolisthesis the roentgenograms do not reveal a slipping of the vertebra Another condition described by Whitman under the name of prespondylolisthesis is really an exaggerated lumbar lordosis Lambl's classification included spondylolysis spondylolisthesis, spondyloschisis and spondyloptosis The term spondylolisthesis imminens is self explanatory

Spondylolysis cannot occur unless there is an interruption of continuity between the vertebral body and the vertebral arch, i.e., congenital intervertebral articular spondylolysis, which is a malformation of the vertebral column frequently observed by the anatomist. This supplies the mechanical prerequisite for a slip of the vertebra.

The anomaly called by Willis "separate neural arch" is an embryonic defect in one or both laminæ which occurs between the superior and inferior articular processes of one of the lumbar vertebræ, most often the last.

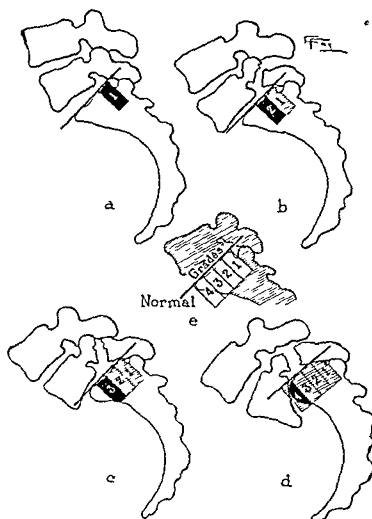


FIG. 228.—At the Mayo Clinic a total of 326 cases (230 males and 96 females) of spondylolisthesis were observed from January, 1918 to May, 1934. They were graded according to the degree of subluxation. (Meyerding, courtesy of *Proc. Staff Meet. Mayo Clinic.*)

Willis' study of the defect substantiated its essential origin in a skeletal anomaly and assigned a minor role to trauma. Embryologically the defect falls into the category of anomalous ossifications. It is peculiar to the lumbar region, but may be found in any lumbar vertebra, on either or both sides but is usually confined to the last presacral vertebra. Trauma (playing a secondary role) finds the fibrous tissue a point of less resistance to strain, than the bone structure.

A separate neural arch is the result of imperfect ossification. At the seventh or eighth week a single center of ossification appears in each half

of the neural arch, near the base of the superior articular process It is recognized first in the cervical portion of the column This extends forward to the centrum, with which is does not fuse until the fourth or fifth year, and backward to the transverse process, lamina and spinous process

Neugebauer in 1881 demonstrated that a separation in the neural arch at the level of the interarticular portion must precede the slipping, and that this congenital cleft formation is found in every case He attributed spondylolisthesis to a defect in the ossification of one or both sides of the arch of the 5th lumbar vertebra or a fracture of the sacral or lumbar articular processes

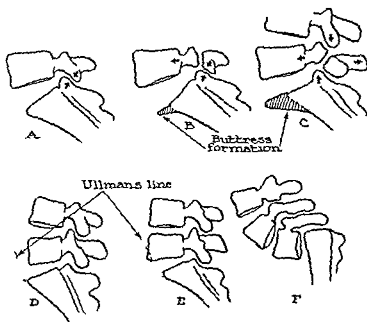


FIG 229 —Spondylolisthesis *A* Diagram to indicate the buttress-like (antiluxation) action of the lumbosacral articular processes *B* and *C* Showing how this action is nullified when interarticular neural arch defects are present Note formation of buttress-like excrescences beneath the last lumbar vertebra (after G A G Mitchell) *D* and *E* Ullman's line The 5th lumbar vertebra should lie behind the vertical line drawn at right angles to the upper border of the sacrum *D* Normal *E* Spondylolisthesis *F* Complete displacement of sacrum posteriorly (Redrawn from Capener Salmon and Contaides British Jour of Surg)

Meyer Burgdorff attributed spondylolisthesis to an acquired (not congenital) chronic bone change with fissure formation in the arch A severe lordosis increases the superimposed load on the transverse articulations and the forces acting on the arch in the lumbosacral region are contributing factors

Chandler reported 18 cases of lesions of the isthmus or interarticular area of the lamina In his series the sex distribution was equal The ages at the time of examination ranged from thirteen to fifty-six, the average being thirty four and a half In 12 cases the onset of symptoms was abrupt, and in all but one of these was associated with definite trauma In every instance a sharp increase in the shearing strain could be anticipated Chandler concluded that solution of bony continuity at the isthmus is common to the lower lumbar spine and impairs the stability and strength of the lumbosacral articulation

Spondylolysis cannot occur, according to Taldim, unless there is an interruption of continuity between the vertebral body and its arch.

All observers have agreed that trauma in some form is the direct cause of the lesion in most instances. Some lesions are due to occupational strain, some to indirect trauma and others to constant labor.

Asbury postulated the change from quadruped to biped as a factor in the causation of spondylolisthesis. The lumbosacral joint is the most frequent site of congenital variations and defects, because here the greatest remodeling takes place in the shortening of the spinal column and elevation of the hind limbs.

Meyerding called trauma a significant factor, although the frequency of congenital defects and the apparent instability of the lumbosacral joint are additional factors. He found the normal lumbosacral angle 36 degrees in the male and 26 degrees in the female. Twenty per cent of his patients showed spina bifida occulta.

One-half the movements of the trunk below the lower thoracic region occur in the lumbosacral joint and the one just above it. In forward bending, motion at the lumbosacral joint occurs chiefly at the articular processes of the 5th lumbar vertebra which slide upward on the opposing processes of the sacrum. Naturally, when the motion is carried too far, the articular processes will be separated and the vertebra can then slip forward on the sacrum. If this action is continued, the last lumbar vertebra may slip entirely off the sacrum, producing spondylolisthesis. The intervertebral disk between the body of the vertebra and the sacrum is an important structure in this mechanism.

Goldthwait emphasized that the lumbosacral articulation varies greatly in stability, depending on peculiarities in the formation of the articular and the transverse processes. If the 5th lumbar slides forward on the sacrum, the condition is usually compensated for and pressure on the cauda equina or the spinal nerve roots does not occur. If the displacement is on one side, the spine must be rotated, and the articular process of the 5th is drawn into the spinal canal with such narrowing that paraplegia may result, or the crowding backward of the intervertebral disk alone may be so great as to cause a similar but more gradual paraplegia. Weakness of the joints or partial displacements of them may cause *irritation of the* nerves inside or outside of the canal, producing bilateral leg pains.

Kleinberg was impressed by the following anatomical facts: the lumbar vertebrae are placed one below the other, with the 5th situated *in a wide* interval between the 4th and the sacrum. The bodies are large, the transverse diameter is longer than the vertical, and they appear quadrilateral. *The sacrum is tilted* forward on a transverse axis so that its superior surface faces upward and forward. The 5th lumbar lying upon the sacrum is also tilted forward, so that its superior surface is directed upward and forward. *In a lateral view the 5th lumbar* appears ready to slip forward off the sacrum and is restrained only by its ligamentous attachments. The lumbar articular processes, placed in the sagittal plane, favor a dislocation.

Goldthwait has shown that the normal anatomical peculiarities and function of the lumbosacral joint in man naturally predispose to subluxation. The articulating surface of this joint slopes at an angle of 30 degrees

of the neural arch, near the base of the superior articular process It is recognized first in the cervical portion of the column This extends forward to the centrum, with which is does not fuse until the fourth or fifth year, and backward to the transverse process, lamina and spinous process

Neugebauer in 1881 demonstrated that a separation in the neural arch at the level of the interarticular portion must precede the slipping, and that this congenital cleft formation is found in every case He attributed spondylolisthesis to a defect in the ossification of one or both sides of the arch of the 5th lumbar vertebra or a fracture of the sacral or lumbar articular processes

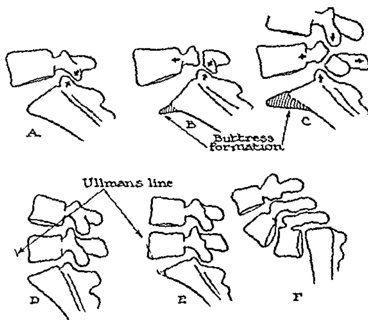


FIG 429 —Spondylolisthesis *A* Diagram to indicate the buttress-like (antiluxation) action of the lumbosacral articular processes *B* and *C* Showing how this action is nullified when interarticular neural arch defects are present Note formation of buttress-like excrescences beneath the last lumbar vertebra (after G A C Mitchell) *D* and *E* Ullman s line The 5th lumbar vertebra should lie behind the vertical line drawn at right angles to the upper border of the sacrum *D* Normal *E* Spondylolisthesis *F* Complete displacement of sacrum posteriorly (Redrawn from Capener Salmon and Contaides British Jour of Surg)

Meyer-Burgdorff attributed spondylolisthesis to an acquired (not congenital) chronic bone change with fissure formation in the arch A severe lordosis increases the superimposed load on the transverse articulations, and the forces acting on the arch in the lumbosacral region are contributing factors

Chandler reported 18 cases of lesions of the isthmus or interarticular area of the laminae In his series the sex distribution was equal The ages at the time of examination ranged from thirteen to fifty six, the average being thirty-four and a half In 12 cases the onset of symptoms was abrupt, and in all but one of these was associated with definite trauma In every instance a sharp increase in the shearing strain could be anticipated Chandler concluded that solution of bony continuity at the isthmus is common to the lower lumbar spine and impairs the stability and strength of the lumbosacral articulation

muscles with ligamentous strain The pain may be localized over the back or referred down the thighs and legs producing "sciatica" and is usually aggravated by physical activity Some patients complain of "tightness" in their legs and pain after walking short distances Meyerding said that severe pain is due either to a congenital anomaly or to a pathological change higher up The patients tire quickly There may be symptoms of bladder irritation Pes cavus may occur On attempting to lift heavy objects from the ground, the patient notes a dragging sensation in the back, and pain radiates down the thighs

Weakness of the joints or partial displacements may cause irritation of the nerves inside or outside the spinal canal, producing bilateral leg pains often called sciatica

In 6 of Chandler's cases the onset of symptoms was gradual but was associated with repeated strains, as in lifting, while the back was partially flexed In all cases symptoms were increased by prolonged standing carrying heavy objects or increased mobility at the lumbosacral juncture Prolonged fixed strains were more incapacitating than frequent changes in position The lumbar pain was described as a dull ache across the posterior aspect of the sacrum, extending laterally to the regions of the sacro-iliac joints In 8 cases definite sciatic radiation pain was present In 5 of these, sciatica was bilateral, 1 patient had bilateral foot drop

Physical Examination —Examination reveals shortening of the lumbar region and a depression at the lumbosacral angle Shortening of the torso, lordosis and a broadened appearance of the pelvis, are common The upper posterior border of the sacrum is unusually prominent A depression due to displacement of the 5th lumbar vertebra, with local tenderness, is common

Usually a well-marked transverse lumbar furrow encircles the trunk, producing folds of skin A definite hollow may be found in the lower lumbar region just above the 1st spinous process of the sacrum The prominence of the postero-superior angle of the sacrum is easily felt and there is an increased interval between this and the spinous process of the last lumbar vertebra, which is apparently displaced upward and forward

Increase of the lumbar lordosis is a common observation, but in one case a total obliteration of the normal anterior curve of the lumbar spine was present When spondylolisthesis was marked, Chandler found a characteristic bony tumor" in the midline of the back Proximal to this was abrupt lordosis Whenever spondylolisthesis was operated on the tumor was found to consist of the spinous process and laminae left in their normal site while the body had advanced anteriorly in relation to the sacrum by separation through the isthmus Muscle spasm was consistent in all but one case Tenderness in the lumbosacral region was a common observation A typical shortening of the back and increased prominence of the buttocks and iliac crests were noted Sensory changes were found in only one case

The outstanding sign, when the condition is fully developed is the telescoped appearance of the trunk The torso is markedly shortened so that the rib margins frequently impinge on the ilia Sometimes there is extreme lordosis of the lumbar spine An abdominal crease is prominent and the iliocostal crease exaggerated The concavity above the sacrum and the

downward and the superior articulating surface of the sacrum is beveled anteriorly *Greater strain is sustained by this joint than any other in the spine* because the superincumbent weight reaches a maximum at this point

In the normal spine the inferior articular processes of the 5th lumbar vertebra hook well over the superior articular processes of the 1st sacral vertebra and this together with the strong ligamentous development, prevents displacement However subluxation of the whole 5th lumbar vertebra may occur in the absence of any congenital defect or variation Subluxation may involve the body alone or the whole vertebra In the former situation, either bifid or separate neural arches are found

Dunlop reported 6 cases in which there was fracture of the lamina Nutavar studied 40 specimens and concluded that there was a fracture of the articular process, possibly with non union Chandler stated that the lesion is a fracture at the isthmus or pars intervertebralis Capener contended that the sacrum may act as a wedge in the production of slipping Edgar emphasized the importance of elongated laminæ Goldthwait pointed out that in unilateral sacralization lateral bending might pry apart the articular processes causing subluxation of the whole vertebra Kleinberg considered the congenital cleft in the pedicles due to lack of fusion of the superior and inferior processes of the 5th lumbar vertebra on one or both sides, the most important congenital morphological variation When anomalies are present the vertebral bodies and the neural arch are held together only by ligaments and may be separated by any injury sufficiently severe to tear or stretch the ligaments An increase in the lumbosacral angle is an important predisposing factor

Sir Arbuthnot Lane found the condition rather common among persons who perform heavy manual labor In fully developed coal heavers, spondylolisthesis may be considered normal Langer estimated that deficient union or absence of union between the vertebral laminæ and the bodies occurs in 10 per cent of skeletons

Pathological Anatomy —Mouchet and Roederer called attention to the shelf-like projection coming off the superior region of the 1st sacral vertebra which acts as a support for the 5th lumbar The cause of this osteophytic formation is a periosteal reaction around the common vertebral ligament There is a pseudo impingement of the 5th lumbar on the sacrum The body of the 5th lumbar vertebra is suspended by or is in a resilient hammock instead of bony support These stretch, their circulation becomes impaired, and they succumb to strain The condition may be partial or complete, with variations of the lumbosacral angle

History—Symptoms —Generally these patients state that their backs have never been perfectly normal and that they have had a peculiar shortness of torso stature

Meyerding described the symptoms as mainly backache, which comes on either gradually or suddenly if suddenly severe trauma is usually associated Absence of symptoms with the patient at rest and aggravation of pain on exertion are characteristic

Symptoms may be slight or severe and appear slowly or suddenly Local or referred pain is due to pressure on or stretching of, nerves and

prominent abdomen and buttocks In backward displacement there is a flat back

The backward prominence of the iliac crests may be slight or noticeable The disturbed equilibrium causes faulty posture The normal pelvic tilt is diminished and the anterior-superior spines are apparently rotated backward through a sagittal arc There may be spasm of the hamstring muscles on attempts at straight-leg raising (the Lasègue sign) There is usually



Fig 231 —Spondylolisthesis with slipping of vertebra and isthmus defect (arrows)

spasm of the erector spinae muscle group and tenderness at the lumbosacral articulation

Some authors have described a waddling gait with widely spread legs as with bilateral congenital dislocation of the hips The gait is different from that in dislocation of the hip, however

Neurological Examination —The neurological signs are usually paresis and modified sensation, commonly limited to the 5th lumbar and 1st sacral segments Complete paraplegia may occur at this level Pain and paresthesia over the saddle area may be present

33

prominent upper border of the sacrum are striking. The pelvis may be widened. Palpation of the spinous processes from above downward reveals a depression just above the lesion. The inclination of the pelvis is lost, and the birth canal narrowed at both inlet and outlet. The pubis is higher than normal, and the sacrum lower. Rotation of the pelvis, caused by tightening of the anterior ligaments of the hip may cause flexion of the thighs. With

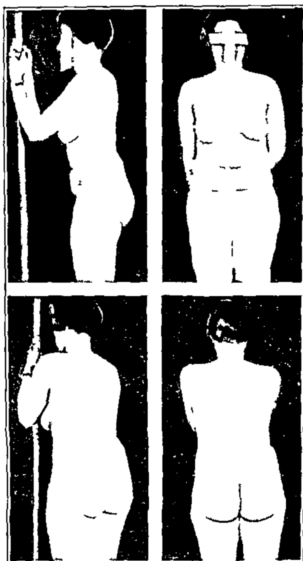


Fig. 230.—Typical posture and conformation in spondylolisthesis.

severe involvement lateral folds may be observed in the back or abdomen and the distance between the ensiform cartilage and the pubis considerably diminished. The umbilicus may be depressed to the level of the crests of the ilia.

Neugebauer considered the combination of lordosis with diminished pelvic obliquity, to be pathognomonic. The deformity of the pelvis and back varies *according to the type of displacement*. In forward displacement there are shortness of the trunk, an exaggerated lumbar lordosis and

Rotary spondylolisthesis a turning and slipping of the vertebrae is caused by an asymmetrical imbalance in the stabilization of the lower spine

SPONDYLOLISTHESIS WITHOUT ISTHMUS DEFECT

Norcross and Potter called attention to a few simple differential points between spondylolisthesis resulting from an isthmus defect and that resulting from erosive changes at the facets, as demonstrated on lateral roentgenograms of the spine

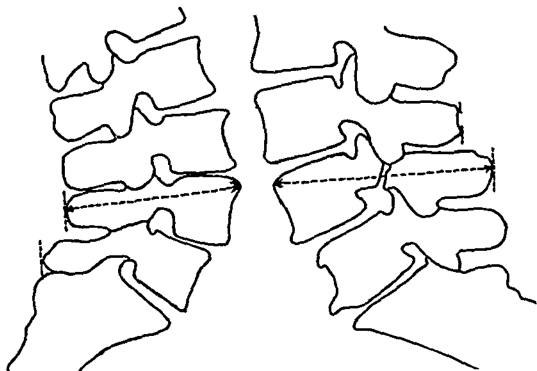


Fig 232 —*Right* In spondylolisthesis due to an isthmus defect there is an increase in the A P dimension of the vertebra *Left* In spondylolisthesis due to degenerative arthritic erosion of facets the A P dimension is not increased (Courtesy of Norcross and Potter Exhibit Am Academy of Orthopedic Surgeons Chicago 1952)

Secondary productive bone reaction may overlap the site of defect or erosive change and obscure the local lesion Reference to shift of the bodies or spinous processes may facilitate the differential diagnosis

Both lesions show forward displacement of a vertebral body In spondylolisthesis resulting from isthmus defect, there is increase in the A P dimension of the vertebra The spinous process of the involved segment remains in normal relationship with the segments below The spinous process of the vertebra one above the involved segment moves forward so that there may be a palpable offset

In spondylolisthesis resulting from degenerative arthritic erosion of facets the A P dimension of the vertebra is not increased The spinous process of the involved segment moves forward with the body The spinous process of the segment below then becomes prominent and may be palpable

Signs of a partial caudal lesion are common, but a complete lesion is rare Only paresis and modified sensation are found The commonest evidence of caudal compression is pain or paresthesia, felt over the distribution of one or both sciatic nerves, the pain being due to hypertonicity or slight weakness of isolated muscles There may be "saddle anesthesia" *In 16 cases reported by Asbury, there was caudal involvement Goldthwait* and Fitch each reported one case of paraplegia secondary to spondylolisthesis Nervous symptoms may be present in sympathetic disturbances of the bowels and bladder

In unilateral spondylolisthesis the early symptoms of paralysis may be so pronounced as to render early diagnosis probable Displacement is such that the spinal canal is narrowed and the cauda equina compressed, with either complete or partial paralysis In bilateral involvement the symptoms are mild There is practically always space for the cauda equina because the change takes place slowly, and paralysis does not often occur

Vaginal Examination—Vaginal examination reveals a diminution of the antero-posterior diameter of the pelvic inlet and when luxation is severe, the displaced vertebral body may be felt projecting above the sacral promontory The antero-posterior diameter of the pelvis is lessened, narrowing the birth canal

Roentgen Findings—Antero-posterior roentgenograms reveal a marked diminution of the height of the 5th lumbar vertebra with a dense double shadow In the lateral projection the sacrum assumes a more vertical position Relations of the facets and neural arch are altered There is usually a deformity of the normally heart-shaped pelvic basin

Lateral, oblique and stereoscopic roentgenograms are desirable

Brailsford described as characteristic the bow-line of the 5th lumbar in antero-posterior roentgenograms projected against the shadow of the flat sacrum It may have the appearance of a helmet

In anterior dislocation the last lumbar vertebra moves downward and forward so that its body overlaps and lies in front of the upper sacral segments while its upper surface faces forward The other lumbar vertebræ will appear as rectangular masses whereas the sacrum seems triangular

In an exhibit of Anatomical Specimens and Radiographs at the American Medical Association Convention held in Chicago in 1952, Hadley emphasized the value of the 45 degree radiograph He described a "Cross' shadow which assists in the recognition of the neural arch defect Bony callus is frequently visualized as a mass projecting into the spinal canal opposite the neural arch defect In the oblique films this is seen posteriorly

Instability and thinning of an intervertebral disk predisposes to reverse spondylolisthesis with foramen encroachment if the posterior articulations are intact Disk instability with posterior joint destruction allows forward slipping usually of L4 the so called pseudo-spondylolisthesis Spondylolisthesis with intact neural arch is also seen with a congenitally elongated isthmus, or in cases of old healed fracture of that structure with a forward displacement of the vertebræ In the absence of lordosis an occult spondylolisthesis may be suspected in patients with a 5th lumbar arch defect wherein the 5th posterior articulation lies well posterior to the plane of the 4th

Rotary spondylolisthesis, a turning and slipping of the vertebra, is caused by an asymmetrical imbalance in the stabilization of the lower spine.

SPONDYLOLISTHESIS WITHOUT ISTHMUS DEFECT

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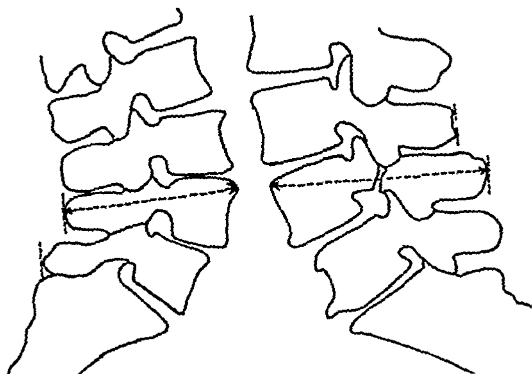


Fig. 232. *Right*, In spondylolisthesis due to an isthmus defect there is an increase in the A.P. dimension of the vertebra. *Left*, In spondylolisthesis due to degenerative arthritic erosion of facets the A.P. dimension is not increased. (Courtesy of Norcross and Potter Exhibit, Am. Academy of Orthopedic Surgeons, Chicago, 1952.)

Secondary productive bone reaction may overlap the site of defect or erosive change and obscure the local lesion. Reference to shift of the bodies or spinous processes may facilitate the differential diagnosis.

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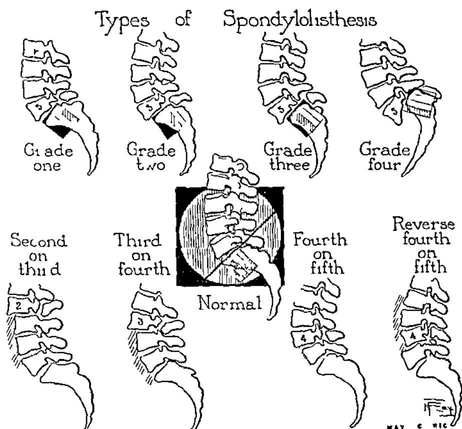


Fig 233 —Gradation of displacements (Meyerding courtesy of Radiology)

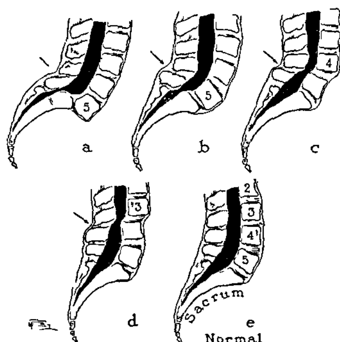


Fig 234 —The effect of spondylolisthesis on the spinal canal sagittal section *a* involving the lumbosacral joint graded 3 *b* involving the lumbosacral joint graded 1 *c* involving the fourth and fifth lumbar vertebræ graded 1 *d* involving the third and fourth lumbar vertebræ graded 2 and *e* normal section through lumbosacral area Arrows indicate depression (Meyerding courtesy of Radiology)

The presence of spondylolisthesis should be determined by a careful examination of the relations of the lumbar vertebra, especially the 5th to the sacrum, as revealed in a lateral roentgenogram In this connection, the so-called Ullman line erected perpendicularly to the anterior border of the 1st sacral segment should not cut off any of the inferior-anterior portion of the 5th lumbar vertebra (see Fig 234)

Diagnosis —Only two roentgenograms, lateral and antero-posterior, are necessary to make a positive diagnosis The latter view is characteristic The body of the 5th lumbar vertebra lies on the sacrum like an inverted boat

Clinical symptoms may give no diagnostic indication in mild cases If the vertebral arch maintains natural relations with the body of the vertebra, only a stereoscopic roentgenogram will reveal the condition

Differential Diagnosis —Before roentgen study, one must consider the presence of arthritis, fracture dislocation and spina bifida From the roentgenograms one must determine (1) whether the lesion is congenital or traumatic or a combination of both, (2) the degree of slipping

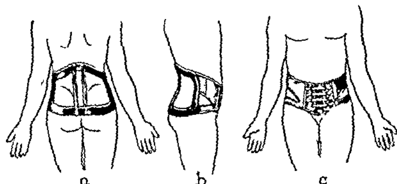


Fig 235 —Rocking-chair type of back support made of steel and leather (Meyerding courtesy of Jour Amer Med Assn)

Course —Spondylolisthesis predisposes to much back disability

Prognosis —The prognosis is excellent so far as relief from symptoms is concerned, but poor as to replacement of the vertebra In men athletics are greatly hampered In women normal pregnancy may be impaired and delivery may be delayed Caesarian section may be required

Prolonged and strict immobilization usually suffices to overcome the disability accompanying both spondylolisthesis and spondylolysis One must remember there is more trouble than the roentgen-ray reveals

Treatment —Non-operative treatment includes pelvic strapping, bed rest use of the Bradford frame traction manipulation support in plaster-of-Paris spine brace or special corsets and physical therapy

With a full realization of the futility of attempts to reduce the displacement and the difficulty of restoring these patients to a state of usefulness by conservative means the best treatment for prophylaxis or severe disability is surgical

SURGERY FOR SPONDYLOLISTHESIS

Bony fixation is the ideal treatment Regardless of whether replacement is accomplished a fusion operation should be performed when feasible

The operations are known by the names of Ryerson, Albee, Hibbs, Mercer, Kure, Speed, Burns, Merle D'Aubigne and combinations of operative technics. For severe disability, some stabilizing operation, such as the Albee massive angular bone graft, the Hibbs fusion, or the Hibbs plus osteoperiosteal or chip double clothes pin graft is indicated (Figs 236 and 237). Lumbosacral fusion is the ultimate goal. Wilson modified the usual procedure to the extent of repairing the defect in the neural arch by using the spinous processes of the 3d and 4th lumbar vertebræ as grafts.

The lumbosacral facets are easily exposed and denuded. After the ligamentum subflavum between the 5th lumbar and 1st sacral vertebræ has been carefully excised and the body of the sacrum exposed, liberal osteoplastic flaps are reflected up and over the denuded laminæ of the 5th lumbar vertebra.

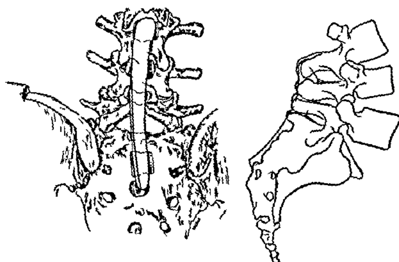


Fig 236.—Single Albee graft across lumbosacral joint. (Campbell's Operative Orthopedics, courtesy of C V Mosby Co.)

Fusion of the 5th lumbar vertebra with the sacrum is sufficient, unless there is definite evidence of displacement of the 4th, with locking of its spinous process to the 5th lumbar vertebra; under such circumstances it is safer to fuse the 4th lumbar vertebra to the 5th and 1st sacral segments. The fusion operation transfers most of the strain from the lumbosacral to the 3d lumbar articulation.

A bone graft produces a new line of weight-bearing from the 2d, 3d and 4th lumbar vertebræ down to the sacrum. Lane performed a laminectomy to relieve compression.

Albee's Operation.—The spinous processes of the lower lumbar vertebræ and the posterior part of the sacrum are laid bare. Exposure is accomplished by turning up a flap consisting of skin and soft parts down to the superficial fascia. The supraspinous and infraspinous ligaments are split. The spinous processes on the posterior surface of the sacrum are likewise located and the ligamentous structures split. With a sharp broad osteotome, the spinous processes of the lumbar vertebræ are split longitudinally. The portion of the spinous process toward the operator is forced laterally toward him. The small spinous processes of the upper two segments of the

sacrum are treated likewise, and their left halves displaced laterally, sufficiently to allow a graft the full thickness of the tibial cortex to be inserted between them

After splitting the spinous processes, the shavings and particles of bone are turned toward one another and the sacrum With an osteotome and curette, the posterior area of the sacrum, with which the graft is to be coapted, is thoroughly scarified Extreme care should be taken to secure an accurate pattern of the posterior part of the sacrum and its angulation

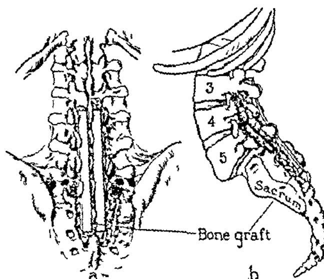


Fig 237 —Operative procedure to produce strong fusion of the lumbar spine (including 3d 4th and 5th lumbar vertebræ and sacrum) by means of double massive bone grafts multiple bone chips and cancellous bone (Meyerding courtesy of Jour Amer Med Assn)

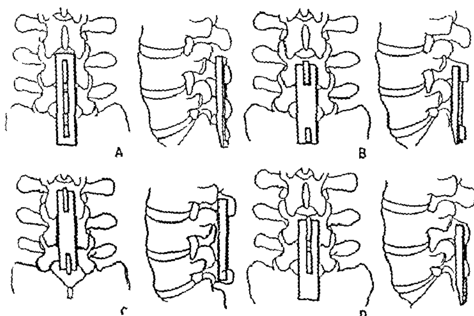


Fig 238 — *A* Inclusion type graft *B* Double clothespin graft set between spinous processes of 4th lumbar and 1st sacral *C* Double clothespin graft set between spinous processes of the 3d lumbar to 5th lumbar bridging laminectomy defect of 4th lumbar Note undercutting of spinous processes *D* Single clothespin graft extending from spinous processes to previous spine fusion below or to sacral surface which lacks spinous processes (Bosworth courtesy of Surg Gynec and Obst)

with the general axis of the lumbar spinal column The spinal wound is then packed with a hot saline compress, and the anterior-internal surface of the central portion of a tibia is laid bare

With a moulded probe as a pattern, the proposed graft is carefully mapped out on the anterior-internal surface of the tibia by strokes of the scalpel through the periosteum As it is desirable to have the sacral end of the graft stronger, this will be the inferior end

As soon as the graft is removed, it is inserted into the bed already prepared for it in the lumbar vertebræ and sacrum It is firmly secured, particularly onto the sacrum, by means of the bone-set and mallet, force being exerted to overcome as much as possible of the spondylolisthetic displacement

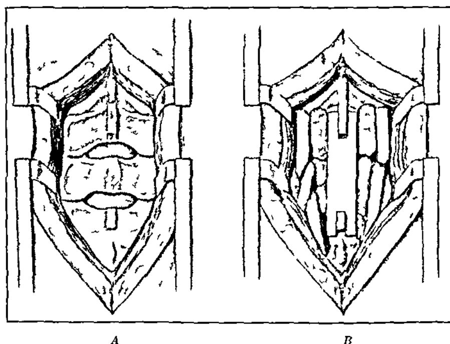


FIG 239 —A Shows the preparation of the posterior elements of spine with squaring off of spinous processes of the 4th lumbar and the 1st sacral and the removal of the spinous process of the 5th lumbar B The implantation of a double clothespin graft which is reinforced with iliac chips (Bosworth courtesy of Surg Gynec and Obst)

The deformity is further corrected by the tension of strong kangaroo tendon sutures which grasp and immobilize the graft thoroughly in the firm ligamentous structures of the lumbar spine and sacrum (Meyerding advised using a double graft extending from the 3d lumbar well down on the sacrum)

The patient is then placed in the dorsal position on a fracture mattress, where he is kept for seven weeks A low corset brace is then applied with a surcingle around the lower end This is worn for from four to six months The operation should be followed by three to four months of recumbency on a Bradford frame or on a hard bed Some surgeons add a Taylor back brace

From an analysis of 59 cases of spondylolysis and spondylolisthesis, Caldwell found that a large percentage of patients with spondylolisthesis can be relieved by conservative measures

From a theoretical viewpoint, the symptoms might in certain cases be relieved by removal of the attached neural arch and the inferior articular processes. Liberation of the nerve roots without fusion of the articulation or bridging of the defect with a bone graft should be supplemented by a low back support.

Mercer's Method.—The patient is placed on his back and the table raised at its lower end to produce an exaggerated Trendelenburg position. A long mid-line incision is made to just above the umbilicus. The abdominal contents are packed off from the area of operation and a self-retaining retractor inserted. The subluxated vertebra is inspected and its relation to the iliac vessels ascertained. The gap between the sacrum and

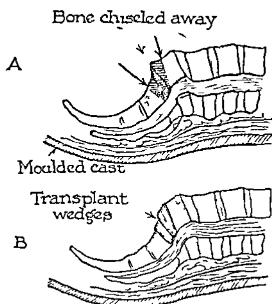


Fig. 240.—*A, Mercer's operation* schematically drawn. The chisel cuts away the shaded area, removing the intervertebral disk and tissues with some bony surface. His description of the operation includes the fact that the patient lies on a previously prepared plaster of Paris shell so that no flexion or angulation of the spine is possible postoperatively. *B*, bone transplants wedged into the defect according to Mercer's description. He apparently intends transplants to hold by surface friction, hence the great care needed in handling the patient after the operation. Flexion at the lumbosacral junction might easily displace the wedges of transplanted bone. (Mercer, *Orthopedic Surgery*, courtesy of Williams & Wilkins Co.)

the slipped vertebral body is exposed by dividing the posterior peritoneum over it, ligating some small veins and the middle sacral artery, and freed of overlying fatty fibrous tissue with a gauze swab. An osteotome is driven in an antero-posterior direction into the lower margin of the fifth lumbar vertebra, at a point an eighth of an inch from its lower edge, and into the upper margin of the sacrum, an eighth of an inch from its upper edge. In this way a rectangular hole is produced after the pieces of bone and the intervertebral disk have been removed. Autogenous bone grafts are taken from the crest of the ilium and wedged into this gap. Two pieces are taken since a single piece cannot be obtained broad enough to wedge in firmly. The grafts are hammered tightly into the gap between the sacrum and the

with the general axis of the lumbar spinal column The spinal wound is then packed with a hot saline compress, and the anterior-internal surface of the central portion of a tibia is laid bare

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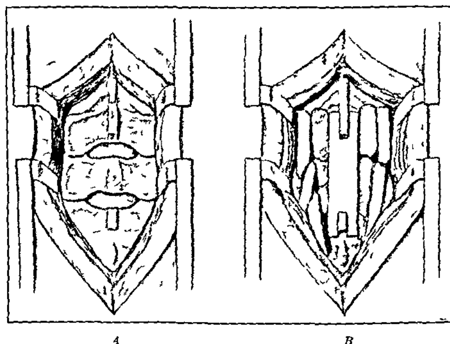


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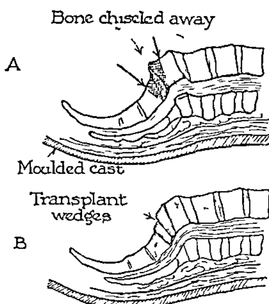


Fig. 240 — *A* *Mercer's operation* schematically drawn. The chisel cuts away the shaded area removing the intervertebral disk and tissues with some bony surface. His description of the operation includes the fact that the patient lies on a previously prepared plaster of Paris shell so that no flexion or angulation of the spine is possible postoperatively. *B* bone transplants wedged into the defect according to Mercer's description. He apparently intends transplants to hold by surface friction, hence the great care needed in handling the patient after the operation. Flexion at the lumbosacral junction might easily displace the wedges of transplanted bone. (Mercer *Orthopedic Surgery*, courtesy of Williams & Wilkins Co.)

the slipped vertebral body is exposed by dividing the posterior peritoneum over it, ligating some small veins and the middle sacral artery, and freed of overlying fatty fibrous tissue with a gauze swab. An osteotome is driven in an antero-posterior direction into the lower margin of the fifth lumbar vertebra at a point an eighth of an inch from its lower edge, and into the upper margin of the sacrum an eighth of an inch from its upper edge. In this way a rectangular hole is produced after the pieces of bone and the intervertebral disk have been removed. Autogenous bone grafts are taken from the crest of the ilium and wedged into this gap. Two pieces are taken since a single piece cannot be obtained broad enough to wedge in firmly. The grafts are hammered tightly into the gap between the sacrum and the

fifth lumbar vertebra and further screwed into place to insure their retention If they are not screwed in, it has been found that when the patient is lifted off the table the lumbosacral gap may be opened up and the wedges of bone spring out To avoid this, in addition to screwing the grafts in the operation is usually carried out with the patient in a posterior plaster shell The patient remains in the shell for four months, and then lies free from restraint in bed for another month Thereafter he is allowed up in a Goldthwait brace

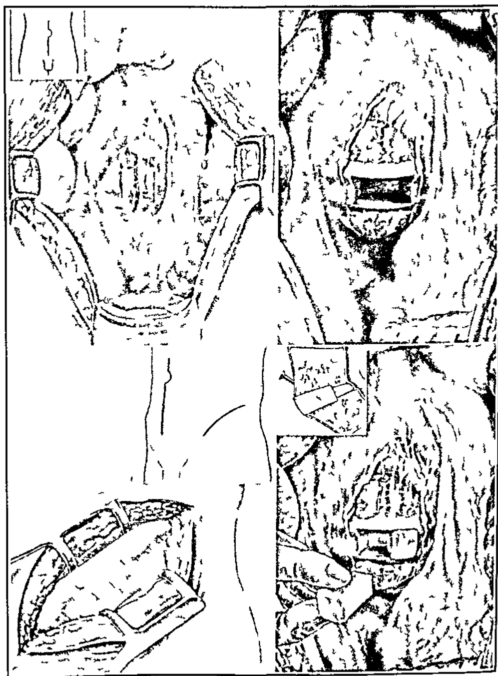


Fig 241 —The steps of the operation for anterior spinal stabilization of vertebrae (Mercer *Orthopedic Surgery* courtesy of Williams & Wilkins Co)

Burns' Operation.—Burns described a method of pegging the bodies of the vertebræ from the front. The abdomen is opened by a left paramedian incision with the patient in the Trendelenburg position. The intestines are packed off and the anterior aspect of the fifth lumbar vertebra exposed by incising the posterior parietal peritoneum, and cleared by blunt dissection, the left common iliac vein being retracted upwards and carefully guarded. A hole is drilled almost vertically downwards through the body of the fifth lumbar vertebra and through it a tibial graft is driven, with a punch. Burns believes that the hammering entailed may produce a partial reduction, or an improvement in the dislocation. He believes it not unlikely that the graft may be absorbed, since he thinks the intervertebral disk is not an ideal situation for a graft. For these reasons he uses a steel pin.

Merle D'Aubigne inserts a long screw diagonally across the bodies of L5 and S1. At the London Convention (1952) he demonstrated his anterior operative approach which was received very favorably. A bolt is better than a screw for stabilization.

REVERSED SPONDYLOLISTHESIS—BACKWARD SLIPPING OF THE FIFTH LUMBAR VERTEBRA—SPONDYLOLISTHESIS POSTERIOR—SACROLISTHESIS—RETROSPONDYLOLISTHESIS

Posterior displacement of a lumbar vertebra, referred to as "reversed spondylolisthesis" or "spondylolisthesis posterior," consists of backward displacement of the cephalad vertebra in relation to the adjacent caudad vertebra.

In 1928 Sicard reported 2 cases of posterior displacement of the fifth lumbar on the first sacral vertebra interpreted as a posterior subluxation of the lumbosacral joint. Mouchet described the condition as sacrolisthesis in which the sacrum lies anterior to the fifth lumbar vertebra. In 1929 Hibbs and Swift reported the results of operations in 6 cases. In 1930, Waindruch and Korezky reported the case of a child eight years old. In this case the condition was clearly congenital. There was an abnormal prominence in the lumbar region and on roentgen examination the fifth lumbar vertebra was found to be completely behind the sacrum and below the upper sacral margin. The body of the fifth lumbar vertebra was hemispherical.

In 1934, Johnson and Smith classified posterior displacement as an independent entity, and emphasized its importance in the causation of backache and sciatica.

In backward slipping of the fifth lumbar vertebra the lumbar lordosis is replaced by a flat back. Ferguson stated that posterior displacement of the fifth lumbar vertebra on the sacrum acts as follows: In the presence of a hypermobile lumbosacral joint, due to the coronal type of articular facets, on hyperextension the fifth lumbar vertebra glides backward on the first sacral vertebra—an exaggeration of the normal motion, while on flexion, instead of gliding forward the vertebra tilts forward as it is caught in the position of posterior displacement.

The anatomical and roentgenological studies of Melamed and Ansfield indicate that the etiological factors responsible for true backward displacement are degenerative processes, disease, trauma and congenital anomalies.

Mouchet reported 3 cases The lateral roentgenogram showed that the sacrum was subluxated forward under the fifth lumbar vertebra and that its superior border made an angle of about 130 degrees with the horizontal The fifth lumbar vertebra was horizontal, its lower border making an angle of about 45 degrees with the upper border of the sacrum Williams and Yglesias found this condition associated with lumbosacral facets in the frontal plane

Following Calve and Galland, Knutsson studied *x*-rays of the spine in hyperflexion and hyperextension

He found a definite percentage of backward spondylolisthesis of L4, *i e*, a reversed displacement Hibbs noted this phenomenon also Knutsson interpreted his findings as indicative of degeneration of the disk below L4 and rotation of the body of L4

In 1944, Knutsson showed that it was a sign of instability of the lumbo sacral junction, associated with disk degeneration Willis believed that actual backward displacement is an optical illusion, due to a relative anteroposterior shortening of the body of the first sacral vertebra

Fletcher demonstrated that posterior displacement of the fifth lumbar on the first sacral vertebra is a definite pathological finding, which is a mechanical consequence of degenerative disk disease He believed that the difference in size of the fifth lumbar and first sacral vertebrae had an etiological significance in the production of these degenerative changes

The treatment is rest and a brace or a fusion operation

Under the name **Spondylolisthesis Lumbalis Acquista,** Unander-Scharin described a case of spondylolysis of the vertebral arch of the third lumbar vertebra which had been shown to be normal on three previous examinations The spondylolysis was observed five years after an osteosynthesis involving the third fourth and fifth lumbar vertebrae and the sacrum The osteosynthesis was performed for pain in the back associated with radiographic signs of degeneration of the fourth lumbar disk

SPONDYLOLISTHESIS IN THE MILITARY SERVICES

During my service in both world wars, I have frequently asked myself the following two questions

1 Does a soldier with spondylolisthesis ever make a good soldier?

2 Does a soldier who has been told he has spondylolisthesis, *ever* make a good soldier?

My answer has been respectively It doesn t make any difference if he remains comfortable or is relieved when pain appears However as soon as he finds himself in an unpleasant situation, his knowledge of his defect will become his point of fixation

TRAUMATIC SPONDYLOLISTHESIS

Spondylolisthesis discovered during adulthood, may be due to an unrecognized lesion sustained in childhood The congenital theory cannot be rejected but the importance of trauma must be admitted

Sicard and Leca consider the isthmus of a vertebra to be its weakest point

CHAPTER 35

SACRO-ILIAC JOINT DISORDERS

Anatomy.—The sacro-iliac joint is composed of the sacrum and the ilium. It is a diarthrodial joint lined with hyaline cartilage and has a capsule, synovial membrane and synovial fluid. It is surrounded and reinforced by the *internal and external sacro-iliac ligaments*. Only slight gliding movements occur. The sacrotuberous, sacrospinous and posterior sacro-iliac ligaments limit the rotary movement of the sacrum on the iliac bones. Relaxation of the ligamentous structures surrounding the joints is common in parturition.



Fig. 242.—Sacrarthrogenetic telalgia. The posterior sacro-iliac and sacro-ischial ligaments (left). The posterior sacral plexus and the innervation of the sacrolumbar and sacro-iliac articulations (right). (Pitkin and Pheasant, courtesy of Jour. Bone and Joint Surg.)

Meckel in 1816 was the first to describe the sacro-iliac joint. Von Luschka was the *first to consider it a true diarthrodial joint. After early adult life* motion almost always disappears, and it becomes amphiarthrodial. In form the articulating surfaces closely resemble the external auricle. They are irregular. The joint cavity is a narrow slit. Kolliker was the first to describe a synovia-like fluid in the joint cavity.

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faces of these joints are covered with articular cartilage, small prominences and hollows articulate with hollows and prominences in the opposing joint surfaces of the ilia.

Sacra viewed from the front show considerable variations in shape. Some are roughly rectangular, others more triangular. In the latter type, the wings of the sacrum, on the external side of which are the sacro-iliac joints, are wider than the lower part. As a result, the sacro-iliac joints are in an oblique plane. In the former, the joints are more nearly vertical and, in consequence more unstable. The direction in which the articular surfaces of the sacro-iliac joints face, is affected by the position and inclination of the pelvis.

Considering the sacro-iliac joints as triangles with two long sides and a narrow base, a horizontal sacrum means that the base of the triangle is facing forward or even downward.

Magnuson described the sacrum as a keystone set in between the two ilia when a person is sitting down. But when the person stands, the back of the sacrum, which is the narrow part above, and the front of the sacrum are not set in between the ilia like the keystone of an arch, with the ligaments as the cause of stability in the sacrum. If the ligaments are cut away, the sacrum will fall in front of the pelvis, in the upright position. The sacro-iliac joints are normally fixed, but obstetricians claim that they can increase the inlet or outlet of the pelvis, by hyperextension, during pregnancy. The ligaments are subject to infections, toxemia, strain and trauma. They are constantly called on to carry a tremendous weight, and when subject to strain they give way much more easily than the ligaments which support other joints, because of this constant demand. When to this is added a toxic or infectious condition, it is easy to see how relaxation of the ligaments around the sacro-iliac joint may occur.

Pathological Changes.—The pathological changes that occur in the sacro-iliac bones and joints may be destructive or productive.

Etiological Factors.—The causes of sacro-iliac conditions are chiefly infection (tuberculosis, arthritis and coccic organisms) and trauma (sudden twists, sprains and strains of the back, pelvis and legs).

Comparatively slight injuries may cause sacro-iliac strain. For example, a doctor standing with his legs abducted lifted his small child from one side of his body and placed him on the other side. This simple act precipitated a severe attack. Persons who stand a-straddle and lift objects from one side to another as structural iron workers do are prone to sacro-iliac strain. Kicking at and missing a football is another cause. The most common injuries occur in the attempt to raise a window that sticks or the lifting of a heavy or cumbersome object like a bicycle from a level below that at which the subject is standing.

Signs and Symptoms.—The symptoms of sacro-iliac disturbances are pain in the region of the joint and pain referred down the back of the thigh and the posterior or outer borders of the thigh and leg producing a limp.

Besides the pain, sensitiveness, tenderness and a limp may be present. Some patients are able to localize the condition definitely, others merely indicate an indefinite pain across the lower part of the back. Most patients with sacro-iliac trouble say their pain is "in the hip." The pain may

Sashin found practically no tissue between the lumbosacral nerve trunk and the sacro-iliac joint except the thin anterior portion of the capsule of the joint, in 257 postmortem examinations.

Hershey found in 64 specimens that the lumbosacral trunk was in direct contact with the sacro-iliac joint at the point where it traverses the joint in its lower third. The upper portion of the piriformis muscle was always found to lie medial to the lumbosacral trunk.

Displacement of the sacro-iliac joint was described in 1870 by Snelling and was comprehensively discussed by Goldthwait in 1905.

Goldthwait proposed a theory of strain, subluxation, or disease of the sacro-iliac joint. Another important contribution was made by Willis who reported anomalies in 7 per cent of 748 anatomic specimens, particularly at the lumbosacral juncture.

Rogers and Cleaves described "the adolescent sacro-iliac joint syndrome." They warned against vigorous treatment and prescribed nothing but rest.

The sacro-iliac joints have strong, resistant and well-developed ligaments. The articular capsule is strong and covers the anterior and part of the proximal and distal aspects of the joint. Posteriorly, the fibers of the capsule are interwoven with the interosseous and posterior sacro-iliac ligaments. Anteriorly, the capsule blends with the fibers of the anterior sacro-iliac ligament, which passes from the outer anterior aspect of the sacrum to the anterior medial border of the ilium. The anterior sacro-iliac ligament is a thin structure.

The lumbosacral plexus lies directly over the lower third of the sacro-iliac joint. At this point nothing except the joint capsule intervenes between the nerve trunks and the joint space and nothing separates the nerves from the bone, except periosteum. Displacements or subluxations are the subjects of much controversy. Barkow was the first to note a tendency of the sacro-iliac joints to fuse.

BIO-MECHANICS OF THE SACRO-ILIAC JOINTS

The sacro-iliac joints bear the entire weight of the body and transmit it to the pelvis and the legs. The joints are large and firm, being held by ligaments but not muscles. There is little motion. Considerable leverage centers *in the sacro-iliac joint. Unexpected leverage transmitted unilaterally* through the hamstring muscles while the body is slightly twisted and curved forward and downward is considered to be a potent cause of sacro-iliac sprain. Walker stated: "This joint supports the weight of the trunk and also absorbs the shocks from the lower extremities. It holds the key position when one is lifting, bending, stooping or walking."

Brown called attention to the sacrum as having always been considered an inverted keystone to the pelvic arch. The sacro-iliac joints are described as auricular-shaped, broadest in the upper part, narrowest in the middle and widening slightly in the lower part. The longest diameter of the joint surfaces is parallel to the body of the sacrum. The shortest is from the anterior to the posterior surface of the sacrum. At the upper end of the sacrum the shortest diameter of the joint is about half as long as the longest diameter, while in the middle of the joint it is one-third or less. The sur-

faces of these joints are covered with articular cartilage, small prominences and hollows articulate with hollows and prominences in the opposing joint surfaces of the ilia

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radiate upward or downward, but especially downward Limitation of motion and stiffness of the lower back are constant

Usually the patient with a unilateral sacro-iliac disturbance sits on the opposite buttock He avoids transmitting weight to the affected side of the pelvis He is unable to lie on the affected side He walks upstairs, one foot at a time, dragging the affected leg after him Straining at stool may aggravate pain in acute traumatic or inflammatory conditions

Physical Findings —Tests for sacro-iliac joint disease include the Lasègue performed by flexing the lower extremity with the knee in extension and the Gaenslen, in which one thigh is held hyperflexed on the abdomen while the other thigh is hyperextended (this produces pain in the sacro-iliac joint) Gratz recommended bi-manual examination while the patient stands with his body flexed The examiner's right index finger is inserted in the rectum for palpation Baer described a tender pressure point in front which he found with every sacro-iliac disorder The point is just lateral and below the umbilicus on the line joining the umbilicus and the anterior-superior iliac spine Pain is referred to the side on which the sacro iliac joint is involved

Smith-Petersen and Rogers found radiation pain over the posterior aspect of the thigh and leg in 77 per cent of cases of tuberculosis of the sacro-iliac joint In only 38 per cent of cases was pain elicited on compression of the iliac crests

In arthritis of the sacro-iliac joint they found the pain in the region of the inferior sacro-iliac ligaments and sacral sciatic notch in 100 per cent of cases, there was almost constant radiation of pain along the distribution of the 1st and 2d sacral nerves the posterior aspect of the thigh and the posterior and lateral aspects of the leg Radiation pain occurred in 89 per cent along the posterior aspect of the thigh, in 81 per cent along the posterior aspect of the leg in 23 per cent along the course of the superior gluteal nerve and in 12 per cent on the lower medial aspect of the thigh When the condition was acute, muscle spasm was always present while the patient was standing This diminished or entirely disappeared during sitting or lying On palpation the inferior sacro-iliac ligaments and the sacral sciatic notch were found to be sensitive in all cases In 71 per cent the range of flexion was increased while sitting, while standing the average increase was 25 degrees The explanation for this difference lies in the elimination of hamstring muscle leverage It is strong evidence against a lumbar or lumbosacral lesion

The straight leg-raising test was positive in 26 cases On the affected side the test showed limitation of excursion aggravation of pain or both On the unaffected side there was less limitation or aggravation In their special tests lateral compression of the iliac crests gave positive results in 52 per cent and rectal examination in 100 per cent, pain was present on hyperextension of the spine in 50 per cent

In discussing the characteristic pains in lesions of the sacro-iliac joint Smith-Petersen said "The patient s description of the distribution of pain cannot be anatomically accurate It is helpful, however when we consider that the innervation of the sacro-iliac joints is derived from the following sources (1) anteriorly, from the lumbosacral cord, (2) posteriorly, from

the 1st and 2d sacral nerves, (3) inferiorly from the superior gluteal nerve, (4) from the obturator nerve"

The opinions of various anatomists differ on the innervation derived from the obturator

On the basis of the innervation Jackson described pain referred along the 4th and 5th lumbar and the 1st and 2d sacral nerves In other words, one may have pain referred along the posterior aspect of the thigh, antero-lateral and posterior aspect of the lower leg and lateral aspect of the ankle Because of the innervation from the superior gluteal nerve there may be pain referred to the sacrosciatic notch, extending in the antero-lateral direction along the distribution of the superior gluteal nerve to its termination in the tensor fasciæ femoris muscle There may also be pain over the distribution of the internal obturator nerve, *i e*, the inferior, medial aspect of the thigh

Smith-Petersen stressed the sites particularly apt to be sensitive in sacro-iliac impairment

1 The inferior sacro-iliac ligament between the posterior-superior and inferior iliac spines

2 Sacrosciatic notch At this point the superior gluteal nerve curves around as it passes forward, and since it sends a branch to the sacro-iliac joint, one may find sensitiveness along the main nerve trunk

3 Sciatic nerve trunk halfway between the ischial tuberosity and greater trochanter, at the level of the gluteal fold

Flexion of the Spine —Smith-Petersen analyzed the movements of flexion of the spine in three positions standing, sitting and lying

Standing —In lumbosacral conditions the muscle spasm is apt to keep the lumbosacral region rigid Forward bending takes place at the hips and in the upper lumbar and thoracic regions In sacro-iliac conditions the patient is apt to bend forward, first by flexing the lumbar spine, then by tilting the pelvis until the hamstrings become taut At this point he either stops because of pain or flexes his knee on the affected side so as to relax the hamstrings, then he is able to bend over farther

Sitting —The difference between flexion while standing and flexion while sitting is that in the latter the hamstrings are relaxed, and consequently no leverage is transmitted to the pelvis With sacro-iliac disorders the patient bends forward freely from the sitting position, even though flexion while standing is markedly limited With lumbosacral involvement attempts at flexion of the spine are limited, the same while sitting as while standing

Lying —Passive lumbar flexion, the examiner flexing the hips on the pelvis is of value in differentiating between lumbosacral and sacro-iliac joint conditions It eliminates muscle leverage to a great extent, and one secures an uncomplicated joint movement better than when the same motion is attempted in the standing and lying positions In lumbosacral conditions this test produces pain, and it is impossible to flex the lumbar spine In sacro-iliac conditions, however, there is no leverage transmitted to the pelvis which moves as a whole Consequently the motion is apt to be free and unaccompanied by pain

Roentgen Findings —The roentgen findings depend on the etiological factors and pathological changes In arthritis one may find atrophy or hypertrophy or a combination of both In tuberculosis a destructive lesion is found if the condition has been present for a considerable time

Roentgen findings include (1) increased density along the margins of the joint, (2) irregularity of the joint line, (3) proliferative change at the inferior margin of the point, (4) disalignment of the pubes

In the majority of cases of acute sacro-iliac strain or relaxation the roentgenograms are negative They may show disalignment, best demonstrated at the pubes When the condition is chronic, proliferative changes are frequently seen along the inferior joint line, at the pubis and at the attachment of the iliolumbar ligaments There may be increased density along the joint line but this is not so common as proliferative changes

Chamberlain claimed that motion in sacro iliac joints can be demonstrated by having the patient stand with one foot on a block Where motion occurs the roentgenogram will show one pubic bone slightly higher than the other

Blaine and Woldenberg reported a group of 18 examples of obliterated sacro iliac joints out of 1800 roentgenograms examined In the early stages of tuberculosis there is increased density along the joint line and in the soft tissues at the inferior margin of the joint In later stages, erosion of the joint line and bone atrophy in the ilium and sacrum occur in addition Gonorrheal arthritis is more apt to involve the entire joint than is tuberculosis, and is frequently bilateral In early stages there is increased density along the entire joint line, more striking than in tuberculosis In later stages there are in addition erosion of the joint line and areas of bony fusion The appearance of early infectious arthritis is similar to that of early tuberculosis In chronic infectious arthritis, however the bone atrophy is much less marked than in tuberculosis

Diagnosis —The diagnosis of sacro-iliac disorders is made on the history the physical examination including special tests, and the roentgen findings

Smith-Petersen stated that the lumbosacral and sacro-iliac joints have a common nerve supply In lumbosacral conditions there may be referred pain along the 5th lumbar and 1st sacral *i e*, anterior aspect of the leg and dorsum of the foot Pain is not usual on the posterior aspect of the thigh which is in the area of distribution of the 2d sacral segment Posterior thigh pain is the most constant referred pain in sacro-iliac involvement Low-back pain with no posterior thigh pain but pain referred below the knee according to Smith-Petersen is suggestive of a lumbosacral condition

Smith-Petersen emphasized the importance of history the type of trauma and the distribution of pain The lumbosacral and sacro iliac regions are subjected to leverage from above as well as from below Leverage transmitted to the hamstrings unilaterally from the pelvis is more apt to cause a sacro iliac condition Leverage applied from above with the spine in flexion is more apt to affect the lumbosacral joint with a lumbo sacral condition The patient can be made more comfortable on either side or on his back With a sacro-iliac disorder as a rule, he cannot lie for any length of time on the affected side As to the distribution of pain, each

spinal joint receives its innervation from the recurrent branches which come off two spinal nerves, the one above and the one below, as they emerge from the spinal foramina The lumbosacral joint receives innervation from the 5th lumbar and 1st sacral segments Lesions affecting the lumbosacral junction are prone to produce pain projected or referred along the distribution of the 5th lumbar and the 1st sacral nerves, *i e* the dorsum of the foot the 1st toe, the medial aspects of the sole and heel (5th lumbar nerve) and the antero-lateral and posterior aspects of the lower leg dorsum of the foot, 2d, 3d, 4th and 5th toes and the lateral aspect of the sole (1st sacral nerve)

Differential Diagnosis —No one sign is pathognomonic of a lesion affecting either the lumbosacral or the sacro-iliac joint and one must depend on history, physical examination, including special tests, and roentgen findings for the differential diagnosis The person with a sacro iliac lesion tells the physician he limps

SACRO ILIAC STRAIN

The term sacro iliac strain is used loosely in describing a large group of disturbances in the lower back The sacro iliac is a true joint and subject to the stresses and strains of other joints but in addition is peculiarly vulnerable to forward and backward bending and especially to torsion or twisting strains which occur in everyday life

A long list of movements and activities may produce sacro-iliac strain for instance, attempting to raise a window that sticks This act is made harder to accomplish when the person is unable to stand squarely in the middle of the window and is compelled to stand on one side and exert his force asymmetrically

Lifting at a mechanical disadvantage with stooping and twisting of the body as in cranking automobiles is a common cause Office workers who attempt to lift a desk to place a rug under it are frequent victims, as are people whose occupations are sedentary and who become unduly enthusiastic about exercise at infrequent and irregular periods trying to make up for lost time A father who engages in rough and tumble tactics with a heavy child is apt to get a sprain of the sacro-iliac joint The structural iron worker who stands on two beams and lifts a heavy keg of rivets while his body is flexed and rotated, may be affected The person who has slept in a bad postural attitude during the night and suddenly jumps out of bed is apt to sprain the sacro-iliac joint when he bends over the basin to wash his face

Roentgenograms should be made in every case, but the doctor and the patient should not be disappointed if the films do not reveal much positive evidence

Treatment includes a support brace or a so called sacro iliac belt or corset with physical therapy including radiant heat massage and inductothermy

Sometimes injection of substances to relax muscle spasm and relieve pain is valuable or manipulation under anesthesia may be required In a certain proportion of cases nothing affords relief except operation This requires a careful selection of cases and a highly specialized technic

spinal joint receives its innervation from the recurrent branches which come off two spinal nerves, the one above and the one below, as they emerge from the spinal foramina. The lumbosacral joint receives innervation from the 5th lumbar and 1st sacral segments. Lesions affecting the lumbosacral junction are prone to produce pain projected or referred along the distribution of the 5th lumbar and the 1st sacral nerves, *i. e.*, the dorsum of the foot, the 1st toe, the medial aspects of the sole and heel (5th lumbar nerve) and the antero-lateral and posterior aspects of the lower leg, dorsum of the foot, 2d, 3d, 4th and 5th toes and the lateral aspect of the sole (1st sacral nerve).

Differential Diagnosis.—No one sign is pathognomonic of a lesion affecting either the lumbosacral or the sacro-iliac joint and one must depend on history, physical examination, including special tests, and roentgen findings for the differential diagnosis. The person with a sacro-iliac lesion tells the physician he limps.

SACRO-ILIAC STRAIN

The term sacro-iliac strain is used loosely in describing a large group of disturbances in the lower back. The sacro-iliac is a true joint and subject to the stresses and strains of other joints but in addition is peculiarly vulnerable to forward and backward bending and especially to torsion or twisting strains which occur in everyday life.

A long list of movements and activities may produce sacro-iliac strain, for instance, attempting to raise a window that sticks. This act is made harder to accomplish when the person is unable to stand squarely in the middle of the window and is compelled to stand on one side and exert his force asymmetrically.

Lifting at a mechanical disadvantage with stooping and twisting of the body as in cranking automobiles is a common cause. Office workers who attempt to lift a desk to place a rug under it are frequent victims, as are people whose occupations are sedentary and who become unduly enthusiastic about exercise at infrequent and irregular periods trying to make up for lost time. A father who engages in rough and tumble tactics with a heavy child is apt to get a sprain of the sacro-iliac joint. The structural iron worker who stands on two beams and lifts a heavy keg of rivets, while his body is flexed and rotated, may be affected. The person who has slept in a bad postural attitude during the night and suddenly jumps out of bed is apt to sprain the sacro-iliac joint when he bends over the basin to wash his face.

Roentgenograms should be made in every case, but the doctor and the patient should not be disappointed if the films do not reveal much positive evidence.

Treatment includes a support, brace or a so-called sacro-iliac belt or corset, with physical therapy including radiant heat, massage and inductothermy.

Sometimes injection of substances to relax muscle spasm and relieve pain is valuable, or manipulation under anesthesia may be required. In a certain proportion of cases nothing affords relief except operation. This requires a careful selection of cases and a highly specialized technic.

SACRO ILIAC SUBLUXATION—"SACRO-ILIAC DISLOCATION"—"SACRO ILIAC SLIP"

While it is possible for a sudden strain on the joint to cause sufficient movement for the irregular joint surfaces of the sacrum and ilium to "catch" and remain sufficiently out of the exact normal position to produce pain and muscle spasm, it is so rare that every diagnostic precaution should be taken to rule out the much more frequent lesions of lumbosacral or iliolumbar sprain or strain

McBride recognizes two distinct types of sacro-iliac subluxations One is a sudden definitely traumatic event, the other a gradual development of relaxation and postural strain disorganizing the mechanical and static forces of body equilibrium between the trunk and the lower extremities In the acute type symptoms arise immediately after some act of sudden lifting while one leg is straight and the other leg slips or after a quick turn or lateral twist of the trunk on suddenly rising from a stooped position Usually the spine is hyperextended while the leg muscles pull on the anterior part of the ilium, thus rotating the ilium forward The postural type is often the result of congenital variations in anatomical structure plus poor general muscular and ligamentous tone Associated postural defects may be flat feet short leg round shoulders heavy abdomen and occupational attitudes producing an abnormal mechanical strain on the back muscles

Cox described two distinct types of sacro-iliac subluxation (1) due to a definite injury (a fall heavy lifting sudden rising from a stooping position or a sitting posture or a sudden lateral twist of the body), (2) due to faulty posture over a long period whereby the sacrum becomes tilted and the lumbar curve is obliterated

Characteristic of the first type is the sudden onset the so-called "stitch in the back" The patient will give a history of having missed a step while coming up the stairs of suddenly arising from the stooped position, of sudden heavy lifting or of a sudden twist of the pelvis due to a fall He is immediately seized with an excruciating pain in the affected sacro-iliac joint and is unable to straighten his body The lumbar lordosis may be obliterated Occasionally the condition may occur suddenly during sleep from lying on the back and thus flattening the lumbar vertebrae The position has necessarily strained the sacro-iliac ligaments and muscles, which soon become so relaxed that definite slipping of the bones occurs, with severe pain The patient is awakened by a severe acute backache usually relieved by stretching or hyperextending the spine

In the second type the symptoms are of slow onset and referred pains do not develop for some time Faulty postures, usually due to the patient's occupation although general lack of muscular tone also may be responsible The sacro-iliac ligaments are put under strain and dull aching is produced At first the pain is due to muscle fatigue but later it is caused by displacement of the sacrum and ilium Such postural defects tend to obliterate the lumbar curve, putting great strain on the ligaments and muscles Patients who are accustomed to sit with the lumbar curve thrown back while driving an automobile are subjects for this type of subluxation

Campbell stated that in examining many thousands of normal and abnormal backs he was never able to elicit the slightest evidence of sacro-iliac relaxation or separation The only separations he saw followed such injuries as being caught between two box cars falling from a horse or being run over by an automobile when gross displacement was apparent in the roentgenogram He expressed doubt that sacro-iliac separation or relaxation really exists except after severe injury or, rarely for a short period during pregnancy

Mechanism —Magnuson described the mechanism of subluxation of the sacro-iliac joints as follows If the ligaments are relaxed when the patient stoops forward there may be a slight slip of the sacrum forward on the roughened joint surface at the upper level There is acute pain in the back, due to the overstretch of ligaments, and because of this pain a muscle spasm immediately occurs On account of both pain and muscle spasm the patient is unable to straighten up, and the sacrum is unable to slip back into place because of the roughened area of the joint The displacement is of course, slight, and will not show in a roentgenogram The pain and disability disappear on manipulation

Cox stated that the mechanics of luxation consist of a definite displacement forward of the ilium from the sacrum at the upper part of the joint, produced by extreme hyperextension of the spine together with the strong muscular pull on the anterior part of the ilium The position is maintained largely by the spasm and the pull of the hamstrings on the tuber ischii, which tend to rotate the ilium forward Epiphysitis of this area may occur in children

Prognosis —One must always be guarded in making a prognosis, especially in industrial cases Complete recovery means absolute relief from symptoms, no limitation of activities and return to former occupation

Treatment —Manipulation under anesthesia is recommended This is followed by protection and support

SACRO-ILIAC ARTHROSIS OBLITERANS

According to Blaine the roentgen manifestations of obliterating sacro-iliac arthrosis represent gross intrinsic joint changes Usually involvement is bilateral Obviously, intimate or microscopic changes cannot be demonstrated by the roentgen-ray regardless of wealth of shadow detail or excellence of stereoscopic effect which prevents conclusions as to the precise changes present In several cases there have been similar joint changes in the lumbar and thoracic joints

The essential alteration is a combination of destructive and constructive changes with both sometimes present simultaneously Roentgen features suggest a low-grade chronic joint infection In some cases shadows apparently indicate active changes, in others, inactive or healed stages of a joint disease

In a differential roentgen study one should consider typhoid arthritis, septic arthritis chronic hypertrophic arthritis and tuberculous disease

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The essential alteration is a combination of destructive and constructive changes with both sometimes present simultaneously. Roentgen features suggest a low grade chronic joint infection. In some cases shadows apparently indicate active changes, in others inactive or healed stages of a joint disease.

In a differential roentgen study one should consider typhoid arthritis, septic arthritis, chronic hypertrophic arthritis and tuberculous disease.

ACCESSORY SACRO-ILIAC ARTICULATIONS

An accessory articulation between the ilium and the sacrum may be present singly or doubly, unilaterally or bilaterally. On the sacrum, articular facets occur in the region of the lateral sacral crest and on a level with the 1st or 2d posterior sacral foramen, on the ilium, on the medial surface of the posterior-superior iliac spine and on the tuberosity, which is the rough area above the auricular surface of the bone.

According to Trotter, accessory sacro-iliac articulations occur in man *in varying percentages according to race, sex and age*. *The articular surfaces* may be covered with either hyaline cartilage or fibrocartilage. The posterior portions of the ilia are less widely separated in pelves presenting the variation than in pelves considered normal. However, these differences are not of statistical significance. Roentgen examination of the pelvis in the living has shown accessory sacro-iliac facets in one case.

NON-OPERATIVE TREATMENT OF SACRO-ILIAC DISORDERS

The non-operative treatment of sacro-iliac lesions consists of rest in bed with the application of leg traction, followed by a plaster-of-Paris spica or a brace, strapping of the pelvis, manipulation and medical gymnastics. In mild sacro-iliac arthritis pain may be relieved by means of adhesive strapping. If this is successful, one should prescribe a special sacro-iliac support and physical therapy. (Manipulations are described on page 111.) All mechanical disturbances of the lumbar spine and of the legs, including flat-feet and pelvic imbalance, must be corrected. The treatment of sacro-iliac strain is rest and support, with heat and massage followed by posture exercises to decrease lumbar lordosis and forward tilting of the pelvis. Usually, mild strain is relieved by strapping, but more commonly a light brace or a well made corset is required for a time. When the lesion is more resistant, the joint must be manipulated under an anesthetic.

Several advantages may be derived from underwater gymnastics: (1) submersion in warm water, which is pleasant to the skin; (2) buoyancy of the water, which eliminates most of the weight of the body; (3) the ability of the patient to move actively, and of the physical therapist to move passively, various portions of the body. Underwater gymnastics may be combined with gentle or forcible manipulation.

Smith-Petersen's Arthrodesis of the Sacro-iliac Joint.—A curved incision is made from the posterior-superior spine along the crest of the ilium, two-thirds of the distance to the anterior superior spine; this incision is carried down to the bone and reflexion of the periosteum started. A second incision from the posterior-superior spine extends in the direction of the fibers of the gluteus maximus for 3 to 4 inches. This incision is carried down through the subcutaneous fat and gluteal fascia; the muscle fibers of the gluteus maximus are then separated by blunt dissection, until the junction of the ilium and sacrum, between the posterior-superior and posterior inferior spines is reached. The superior gluteal nerve and artery emerge at the anterior portion of the sacrosciatic notch and give off posterior branches which are encountered in the straight limb of the incision, and which may

be torn during dissection or retraction. The flap thus outlined is reflected subperiosteally, exposing the posterior portion of the lateral surface of the ilium. If the sacro-iliac joint is projected on the lateral surface of the ilium, the inferior border will be found to correspond with the sacrosciatic notch, and the anterior border with the median gluteal line. The superior border is not of importance, because these two landmarks sufficiently determine the location of the joint. A rectangular window is now cut through the ilium within the projected area of the joint. The

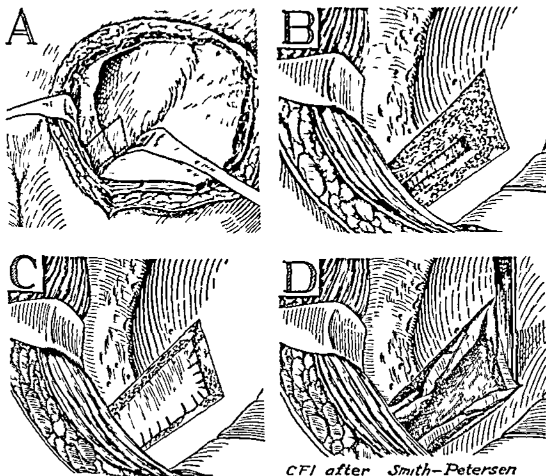


Fig 243.—Smith Petersen's intra articular arthrodesis of sacro iliac joint. *A* Outline of section of bone removed from ilium, sacro iliac joint and sacrum. *B* after removal of bone plug. *C* Cartilage resected from joint surface and block of bone replaced and countersunk. *D* Edges of window osteotomized and fragments turned inward. (From Campbell's Operative Orthopedics, courtesy of C. V. Mosby Co., redrawn from Smith Petersen and Rogers.)

thickness of the ilium just above the sacrosciatic notch is considerable, sometimes as much as an inch, but if care is taken the entire block of bone from the outer to the inner table of the ilium may be removed in one piece, exposing the cartilaginous joint surface of the sacrum. The cartilage of the sacrum as well as its cortex is next removed, bringing about a good exposure of cancellous bone. This procedure results in a rectangular channel bordered on both sides by cancellous bone, extending from the ilium through the sacro-iliac joint into the sacrum. After removal of the cartilage and cortex from the block of bone, the block is replaced in

the ilium and countersunk, so that its cancellous surface will be in contact with the cancellous bone of the sacrum

The flap is then returned to its place, and the periosteum and soft parts are sutured in layers

In purulent infections of the joint, the window is cut in a direction parallel with the sacro-iliac notch In cases of tuberculosis it is better to cut the window at an angle, as a better dowel is thus obtained In tuberculosis, the curette is used extensively to reach the parts of the joint not actually exposed

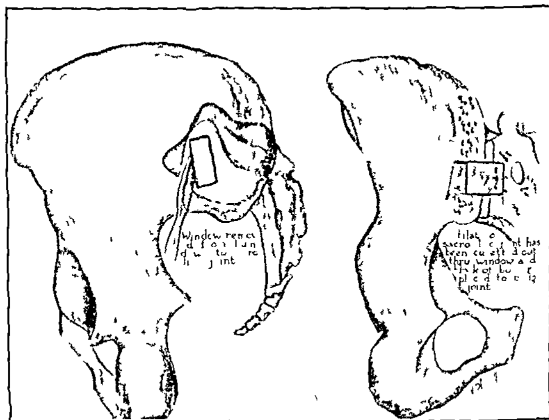


Fig 244 —Sacro iliac operation Smith Petersen s operation (Steindler *Orthopedic Operations* courtesy of Charles C Thomas)

The patient remains in bed three weeks wearing an abdominal binder At the end of three weeks he is allowed up and about wearing a sacro iliac belt with a pad over each gluteal region He usually leaves the hospital four weeks after the day of operation

Gaenslen's Operation —The incision is made just above the posterior two-thirds of the iliac crest and extends well down past the posterior-inferior spine The posterior portion of the ilium is then split flatwise with a broad chisel into an inner and an outer leaf and a large flap consisting of skin and muscle The outer leaf of the ilium is deflected outward With a chisel the medial portion of the ilium overlying the joint is removed, exposing the sacro-iliac joint The latter is completely destroyed, the resulting bone defect being filled with healthy bone fragments Closure is

accomplished by turning the large flap upward into place and suturing in layers The integrity of the joint so far as the ligamentous support is concerned is not interfered with

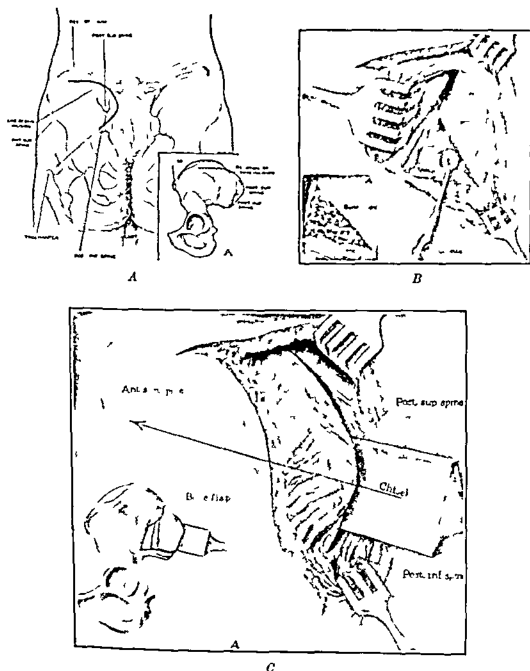


Fig 245 —Sacro-iliac arthrodesis Line of skin incision with reference to landmarks *A* Division of posterior third of ilium into an inner leaf which remains standing and an outer leaf which is deflected *B* The outer leaf of the split ilium is deflected laterally A triangle is now marked out on the standing leaf of the ilium by three chisel cuts This triangle see inset of B lies roughly within the articulating area of the joint The first cut lies on a line connecting the posterior inferior spine of the ilium with the anterior superior spine The second arises from the front end of the first at slightly less than a right angle to this The third line completes the triangle *C* Exposure of sacro-iliac joint and removal of articular surface with curette The inset shows the joint packed firmly with healthy bone chips Outer bone plate is replaced and fascia closed with plain catgut Initial suture of the superficial fascia The skin is closed with a continuous silk suture (Gaenslen courtesy of Jour Amer Med Assn)

Campbell's Operation —Campbell's operation is extra-articular It fuses the wing of the sacrum with the dorsum of the ilium Campbell makes a raw gutter between the sacrum and ilium, into which is inserted a portion of the iliac crest He uses the inner portion of the crest or the posterior portion of the ilium to fill in the triangular-shaped gutter between the overhanging portion of the ilium and the posterior surface of the sacrum

The technic follows An incision is made along the outer lip of the crest of the ilium from the posterior one-third or one-half to the posterior-

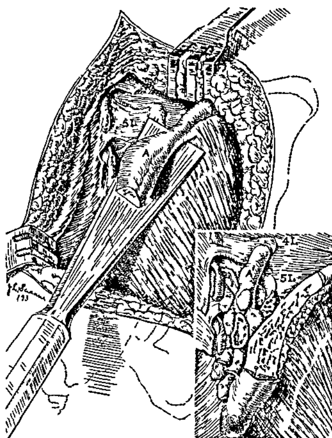


Fig 246 —*A* Fusion of lower lumbar vertebræ and sacrum by means of a curved graft from crest of ilium *B* Removal of posterior portion of the crest of the ilium Insert shows removed portion of ilium *A* lying on denuded urfaces of sacrum and transverse processes of 4th and 5th lumbar vertebræ Multiple chips are placed about the portion of the ilium and into the denuded gutter (Campbell courtesy of Surg Gynec and Obst)

inferior spinous process This is carried down to the bone where the periosteum is incised and elevated for a considerable distance, and the posterior portion of the dorsum of the ilium exposed The crest of the ilium is dissected free to the raw bone and the adjacent fibrous tissue removed from the posterior surface of the sacrum beneath the region of the erector spinæ or sacrospinalis muscle A portion of the crest is removed and placed in a towel The inner surface of the overhanging portion of the crest of the ilium is denuded and a raw gutter made parallel with the sacro-iliac joint formed by the posterior surface of the sacrum and the inner surface of the ilium posterior to the sacro iliac joint In this space

is placed the graft from the crest Multiple grafts of shavings from the dorsum of the ilium are placed in the gutter until the space is filled, the wound being closed in layers The patient is placed on a Bradford frame for six weeks, when a low-back brace with a sacro-iliac belt is applied

Gibson's Operation —A curved incision exposes the area and the electric saw removes the portion of the ilium which projects posteriorly The adjacent portions of the sacrum and ilium are then freshened and the detached piece of bone is jammed in between them, no sutures being used to keep the graft in place

Ryerson said that choice in sacro-iliac operations depends on whether one or both joints are to be operated on If only one joint is concerned, the Smith Petersen technic is recommended, if both, the Campbell fusion operation is preferred

SACRO-ILIAC INFECTIONS—SACRO-ILIAC ARTHRITIS—SACRO-ILITIS

Arthritis of the sacro-iliac joint is very common The most important etiological factors are infection, postural defects and trauma The pathological changes may be destructive or productive

The symptoms are usually pain, sensitiveness, tenderness and limp The physical findings are pain, tenderness, limitation of movement as revealed by the various tests including the Lasègue and other tests The roentgen ray may reveal atrophic or hypertrophic changes The diagnosis rests upon the history, the physical findings and the roentgen-ray examination The differential diagnosis includes differentiating other diseases from arthritis especially from tuberculosis, and from lesions of other regions such as the lumbosacral joint and from the intervertebral disk syndrome

The treatment consists of rest in bed with the application of leg traction A plaster-of-Paris spica or a brace and in some cases, fusion operation either by the method of Smith-Petersen Gaenslen or Hibbs Usually a mild sacro iliac arthritis can be treated in the office by means of an adhesive strapping as a therapeutic test If this gives relief, one should prescribe a special sacro-iliac support

All mechanical disturbances of the lumbar spine and of the legs, including flat feet must be corrected

The general impression that the majority of sacro-iliac infections are tuberculous is dispelled by careful study of the region The sacro-iliac area is vulnerable to all coccus infections Epiphysitis may lay the groundwork for future mechanical trouble Sacro-iliac tuberculosis is rare in childhood in spite of the frequency of tuberculosis

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

Symptoms —The chief symptom of tuberculosis of the sacro-iliac joint is pain usually referred to the hip and aggravated by standing walking and compression separation or twisting of the ilia There may be sciatic nerve pain Smith-Petersen and Rogers called it "sciatica with 1st and 2d sacral pain" The 4th and 5th lumbar nerves are not involved in this radiation pain, nor is pain referred to the anterior aspect of the leg and



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dorsum of the foot. Only two-fifths of the sciatic nerve is involved. These authors stated: "The almost constant finding of radiation pain over the posterior aspect of the thigh and leg is of importance, because of its diagnostic value in any sacro-iliac joint condition, whether traumatic or inflammatory." Since this distribution of pain was present in 77 per cent of the cases of tuberculosis of the sacro-iliac joint, Smith-Petersen and Rogers concluded that this so-called "sciatica" is typical of any condition involving the sacro-iliac joint. Listing may or may not be present, sometimes toward and sometimes away from the affected side.

There is a possible relation between bladder innervation from the 2d and 3d sacral nerves and the innervation of the sacro-iliac joint. In 3 cases Smith-Petersen and Rogers reported relief of urinary retention by operation.

Limp.—Scoliosis is usually produced, the gait is shuffling, the knees may be held close together and the patient takes short rigid steps. The pelvis is immobile. Stooping may be difficult. Flexion at the thigh may be present, with or without adduction. An abscess may form.

Physical Signs.—These authors found the inferior sacro-iliac ligaments and sacrosciatic notch sensitive to palpation in all cases. In none was there sensitiveness at the lumbosacral junction. Such a negative finding is as important as a positive one. The entire gluteal region and the lower abdominal quadrant were sensitive to palpation in 2 cases, both associated with psoas and gluteal abscesses. No aggravation of pain on forward bending while standing or sitting was present in 2 of 11 cases. Usually there was an increased range of motion in the sitting as compared with the standing position.

Passive lumbar flexion of more than 145 degrees was present in 50 per cent of cases. If the pelvis was moved as a whole and the hamstrings were relaxed, no leverage was transmitted to the sacro-iliac joints, consequently there was no pain. Limitation of lumbar flexion (present in 50 per cent) was associated with the acute stage and such sensitivity over the sacro-iliac joint that pressure of this region against the table was unbearable.

Straight-leg raising was limited by 25 degrees on the average considering the normal range as approximately 70 degrees with the horizontal plane. Whenever straight-leg raising is markedly limited in inflammatory conditions as in tuberculosis, it is apt to aggravate the pain when performed on the affected and the unaffected sides, the difference between the two sides averaging no more than 1 degree.

In only 38 per cent of cases was pain elicited on compression of the iliac crests. A positive response to this test is distinctly in favor of a sacro-iliac lesion, but a negative response does not rule out such a lesion.

Rectal examination may show thickening of the anterior sacro-iliac ligaments. An abscess under the gluteus maximus muscle may point in the sacro-iliac region and break into the rectum; a psoas abscess may be found.

Roentgen Findings.—Characteristics, according to Smith-Petersen and Rogers, are: (1) increased density along the margins of the joint, (2) irregularity of the joint line, (3) proliferative changes at the inferior margin of the joint, (4) disalignment of the pubes. In 4 of their 26 cases there were no such signs.

Pyogenic Osteomyelitis of the Sacro-iliac Joint.—About 20 cases of pyogenic osteomyelitis of the sacro-iliac joint have been observed by Kulowski. Involvement secondary to a neighboring suppurative process, particularly involvement of the lower lumbar vertebrae, warrants emphasis. Rectal examination is important in detecting tenderness and abscess formation. The depth of the lesion, the insufficiency of its clinical signs and its progressive character prove the futility of treatment other than radical resection.

Bardenheuer in 1899 was the first to urge radical resection of the sacro-iliac joint, in this instance for tuberculous involvement. The technic is essentially a subperiosteal resection of a posterior iliac flap and the sacral portion of the joint. The approach is posterior through a modified Sprengel type of incision. The posterior half of the ilium is subperiosteally stripped on both intrapelvic and extrapelvic aspects, exposing the sciatic notch. The ilium is sectioned vertically with a Gigli saw, which is passed through the lateral border of the greater sciatic notch.

Avila's Antero-lateral Approach to the Pyogenically Infected Sacro-iliac Joint.—With the patient in the supine position, an incision 4 or 5 inches long is made ½ inch above, and parallel to, the crest of the ilium, starting over the anterior-superior iliac spine. The inferior edge of the wound is dissected down, and the attachments of the abdominal muscles to the crest are cut over the superior border of the ilium, but not on its outer aspect. This leaves the skin flap and underlying structures attached to the crest of the ilium, thus preventing the retraction of the lower edge of the incision. The aponeurotic attachments of the abdominal muscles are cut, and the periosteum is incised at the same level; then with a periosteal elevator, the iliacus muscle is stripped subperiosteally, following the anterior aspect of the ilium medially and slightly downward. This muscle is retracted medially, and from then on the periosteal stripping is carried out by the gloved finger. The operator goes deep enough to find the lateral attachments of the anterior ligaments of the joint; these are cut or detached with the periosteal elevator. The joint can then be explored in all its length. By extending the incision further back, with good retraction, the articular surfaces of the ilium and sacrum can easily be exposed. The wound is left open and packed with petrolatum gauze.

Chandler reported a case of pneumococcus infection of the sacro-iliac joint.

Hatcher described a lesion that looked like infectious arthritis of the sacro-iliac, but turned out to be sarcoma.

LUMBOSACRO-ILIAC ANGLE LESIONS

The lumbosacro-iliac angle is formed by the 5th lumbar vertebra, its transverse process, the top of the sacrum and a small portion of the ilium.

Disturbances at this location may be traumatic, infectious, congenital, metabolic, circulatory or neoplastic, the most important being mechanical and traumatic. The injuries may affect the bones, joints, ligaments, muscles, bursa, the fat, the nerves, disks and the blood vessels.

dorsum of the foot Only two-fifths of the sciatic nerve is involved These authors stated "The almost constant finding of radiation pain over the posterior aspect of the thigh and leg is of importance, because of its diagnostic value in any sacro-iliac joint condition, whether traumatic or inflammatory" Since this distribution of pain was present in 77 per cent of the cases of tuberculosis of the sacro-iliac joint, Smith-Petersen and Rogers concluded that this so-called "sciatica' is typical of any condition involving the sacro iliac joint Listing may or may not be present, sometimes toward and sometimes away from the affected side

There is a possible relation between bladder innervation from the 2d and 3d sacral nerves and the innervation of the sacro-iliac joint In 3 cases Smith-Petersen and Rogers reported relief of urinary retention by operation

Limp —Scoliosis is usually produced, the gait is shuffling, the knees may be held close together and the patient takes short rigid steps The pelvis is immobile Stooping may be difficult Flexion at the thigh may be present, with or without adduction An abscess may form

Physical Signs —These authors found the inferior sacro-iliac ligaments and sacrosciatic notch sensitive to palpatation in all cases In none was there sensitiveness at the lumbosacral junction Such a negative finding is as important as a positive one The entire gluteal region and the lower abdominal quadrant were sensitive to palpation in 2 cases both associated with psoas and gluteal abscesses No aggravation of pain on forward bending while standing or sitting was present in 2 of 11 cases Usually there was an increased range of motion in the sitting as compared with the standing position

Passive lumbar flexion of more than 145 degrees was present in 50 per cent of cases If the pelvis was moved as a whole and the hamstrings were relaxed no leverage was transmitted to the sacro-iliac joints, consequently there was no pain Limitation of lumbar flexion (present in 50 per cent) was associated with the acute stage and such sensitivity over the sacro-iliac joint, that pressure of this region against the table was unbearable

Straight-leg raising was limited by 25 degrees on the average considering the normal range as approximately 70 degrees with the horizontal plane Whenever straight-leg raising is markedly limited in inflammatory conditions as in tuberculosis it is apt to aggravate the pain when performed on the affected and the unaffected sides the difference between the two sides averaging no more than 1 degree

In only 38 per cent of cases was pain elicited on compression of the iliac crests A positive response to this test is distinctly in favor of a sacro iliac lesion, but a negative response does not rule out such a lesion

Rectal examination may show thickening of the anterior sacro-iliac ligaments An abscess under the gluteus maximus muscle may point in the sacro iliac region and break into the rectum a psoas abscess may be found

Roentgen Findings —Characteristics, according to Smith-Petersen and Rogers, are (1) increased density along the margins of the joint (2) irregularity of the joint line (3) proliferative changes at the inferior margin of the joint (4) dislignment of the pubes In 4 of their 26 cases there were no such signs

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tips of the spinous processes of the 4th and 5th lumbar and 1st and 2d sacral vertebræ. The spinous processes of the vertebræ and contiguous laminæ are then completely exposed posteriorly by subperiosteal dissection which is carried laterally exposing the margins of the lateral vertebral articulations. The interspinous ligaments, as well as the ligamentum flavum are carefully curetted from between the adjacent laminæ and the cartilage of the lateral articulation is removed with a small curette or chisel. Bone bridges are chiseled from the adjacent margins of the exposed laminæ. These are interlocked spanning the interlaminar spaces. The

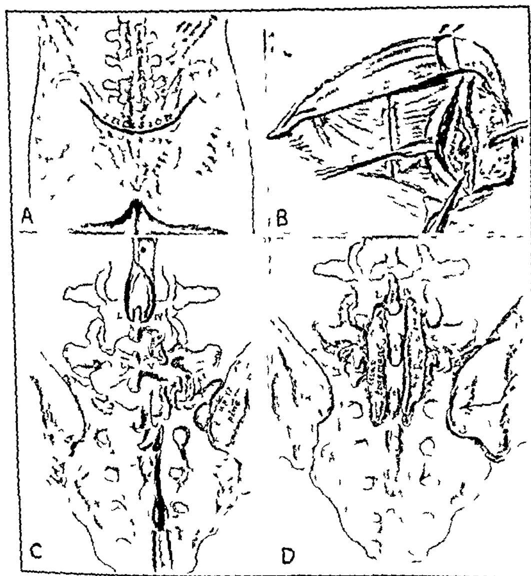


Fig 247.—Trisacral fusion. *A* Transverse incision through skin and subcutaneous tissue exposing lumbosacral and both sacro iliac regions. *B* Bony bridges are turned up spanning the interlaminar spaces. The lateral articulations are curetted and the spinous processes are partially amputated. *C* The external portion of the ilium is reflected laterally and the internal portion excised. *D* The periosteum of the sacrum is reflected medially and the cartilage of the sacro-iliac joint curetted. Cancellous bone chips fill the iliosacral angle. The reflected portion of the ilium is brought medially covering the posterior portion of the sacro iliac joint and sutured to the periosteum of the sacrum. The excised fragment of the ilium is divided and placed so as to reinforce the spine fusion operation. (Chandler, courtesy of Surg. Gynec. and Obst.)

There may be fractures, dislocations, subluxations, disturbances of the facets, calcification of the ligaments, sacralization of the 5th lumbar, lumbarization of the 1st sacral segment, bursitis and episacro-iliac lipomas In the light of recent developments, the most important lesion is probably the disk syndrome

After disturbances in the lower part of the back from any cause, have persisted for long periods, the three regions may become involved due to the reciprocal relation of factors of stress, strain and contiguity The pathological changes depend on the cause and may involve bones, joints, ligaments, muscles, fasciæ, nerves and vessels

The symptoms include pain over a large area which cannot be definitely localized Many patients with low-back pain say the pain is across the lumbosacral region and indicate both sacro-iliac areas in addition They also have tender areas in these three locations In addition to pain and tenderness, there is weakness of the back, and the patient is unable to remain in one position for a long period Some patients say the back feels as though the body were disjointed or loosely jointed

Physical signs are limitation of motion especially of the leg The various tests, the Lasegue, Kernig and the fabere-Patrick signs, are usually positive

Roentgen findings may suggest trauma, infection, and atrophic, hypertrophic or destructive areas

More accurate and specific differentiating signs, symptoms and tests should be devised so that conditions affecting one or more of these joints may be diagnosed early This will reduce the number of operations on all three joints

In the differential diagnosis one should emphasize the importance of localized points of pain and tenderness

The same principles of treatment apply here as in sacro-iliac lesions If non-operative procedures fail, operation is indicated Operation on the three joints—which is a long process—is a combination of the methods of Hibbs Albee Gaenslen Campbell and Delagenière Chandler's operation of trisacral fusion makes possible the bony consolidation of the ilia and lower lumbar vertebræ It has been found most practicable to fuse the last two lumbar vertebræ to the sacrum although the extent of fusion should be determined by the individual case

Trisacral Fusion, Chandler's Operation —The patient is placed prone on the operating table with a small sandbag under the lower abdomen to reduce the lumbar lordosis A transverse crescentic skin incision is made along the posterior margin of the iliac crests crossing the midline 1 inch below the level of the posterior-superior spines of the ilia The subcutaneous tissues are divided along the same line until the gluteal and sacrospinalis fasciæ are exposed The convex flap is then dissected from the fascia in the midline only enough to expose the tips of the spinous processes of the lower lumbar vertebræ The margins of the concave flap are freed at their lateral ends giving a good exposure of the posterior-superior spines of the ilia

Lumbosacral Fusion —This stage of the operation closely follows the technic of Hibbs' spine fusion A vertical incision is made exposing the

tips of the spinous processes of the 4th and 5th lumbar and 1st and 2d sacral vertebræ. The spinous processes of these vertebræ and contiguous laminæ are then completely exposed posteriorly by subperiosteal dissection which is carried laterally, exposing the margins of the lateral vertebral articulations. The interspinous ligaments as well as the ligamentum flavum are carefully curetted from between the adjacent laminæ, and the cartilage of the lateral articulation is removed with a small curette or chisel. Bone bridges are chiseled from the adjacent margins of the exposed laminæ. These are interlocked spanning the interlaminar spaces. The

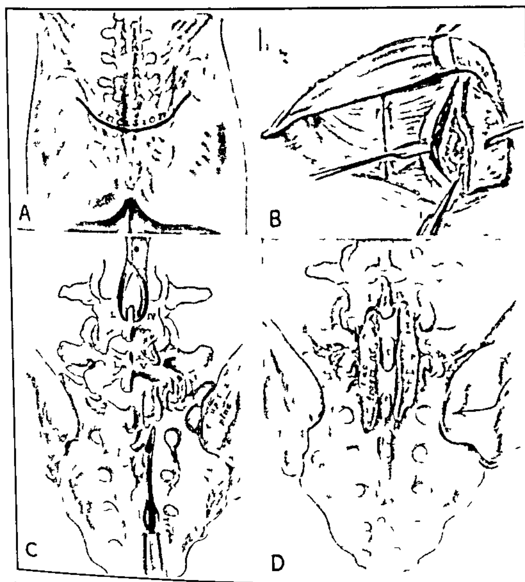


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spinous processes are partially amputated The fragments of the spinous processes are broken down, supplementing the laminar bridges on either side The midline incision is closed with two temporary sutures, which approximate the fascia and periosteum

Sacro-iliac Fusion —When freed, the attachments of the gluteal and sacrospinalis fasciæ expose the posterior-superior spine of the ilium, which is split parallel to its flat surfaces The outer portion, reflected laterally, is hinged by the periosteum and gluteus maximus muscle at the level of the posterior margin of the sacro-iliac joint The inner portion of the ilium is excised and after the portions of the posterior sacro-iliac ligaments are divided, it is removed from the wound and preserved in normal saline solution for later use Hemorrhage is controlled by hot packs and pressure while the opposite joint is treated in a similar manner

The periosteum of the posterior surface of the sacrum is elevated toward the midline and the cortex of the sacrum roughened by means of a small gouge The posterior margin of the cartilage of the sacro-iliac joint is seen in the depth of the wound and is curetted thoroughly Chips of cancellous bone from the ilium are placed across the sacro iliac joint posteriorly, and the reflected bone flap of ilium is turned against the roughened surface of the sacrum, and the periosteum of both iliac bone flap and sacrum is sutured The iliospinalis and gluteal fasciæ are then approximated with catgut sutures The opposite sacro-iliac joint is treated in a similar manner The excised portion of ilium not used for chip-grafts is split into two portions which are inserted through the midline incision, so as to lie adjacent to the stumps of the spinous processes The midline and lateral incisions are closed and the skin incision sutured with interrupted chromic catgut

FIBRO FATTY TISSUE ACCUMULATIONS IN THE BACK

Fatty tissue is widely distributed and constitutes nearly 20 per cent of the body weight It has been established that human fat can retain water to a remarkable degree

Copeman and Ackerman gave the following anatomical description Deep to the subcutaneous fat and areolar tissue lies a highly vascular sheet of fascia which stretches from the neck to the gluteal region The space between this and the deep fascia contains little or no fat In certain well defined places deposits of pinkish fibro-fatty tissue occur regularly, and it is these regions together with the equally constant deep ones which constitute the basic fat pattern ' In obese persons this fat pattern tends to become obscured

Copeman proved that fat tissues are subject to pathological variations which cause pain

It has been shown that several recognizable rheumatic syndromes can be due to an abnormal retention of fluid by fat lobules in certain situations When this occurs they endeavor to swell but being confined by indistensible fibrous tissue they are unable to do so and the tension pain results This edema is not inflammatory in nature

In some such cases a defect occurs in the fibrous covering resulting in herniation of the enclosed fat lobule into an adjoining layer Such herniations may be pedunculated nonpedunculated or foraminal

The origin of this selective swelling is probably endocrine The direct effect of cold may unmask it

The syndromes described as being due to this abnormality of fat are (*a*) 'fibrositis' which occurs in any of the several normally occurring fat-pads and (*b*) panniculitis which occurs in abnormally deposited fat Panniculitis may occur with or without general obesity

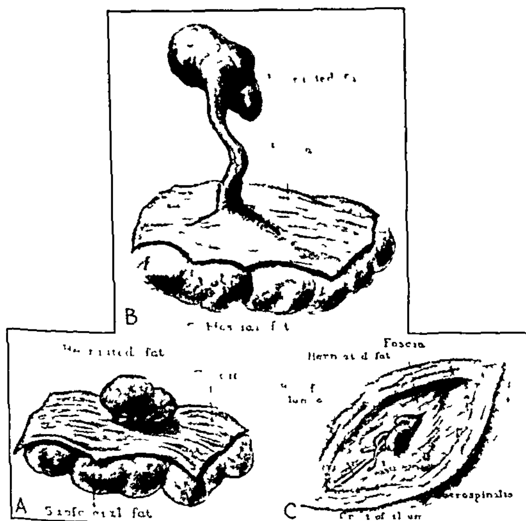


Fig 248 — 4 The non pedunculated type of fat hernia *B* the pedunculated type of fat hernia *C* the foraminal type of hernia (Copeman and Ackerman courtesy of A M A Arch Int Med)

EPI SACRO ILIAC SUBFASCIAL LIPOMAS (E S I-L BODIES)

E-S-I-L is a word made up of the initials of epi-sacro-iliac-lipoma E-S-I-L bodies are fatty masses found in the regions of the posterior-superior iliac spines, and along the medial borders of the lower portions of the erector spinæ muscles They can cause low-back pain and local and referred pain and tenderness The symptoms may simulate sciatic neuritis and the disk syndrome

Ries and Lifvendahl called attention to this condition in 1936 They relieved a large number of patients of backache with novocaine injections

If the pain returned, they advised excision of the masses which was followed by relief of symptoms

The importance of the condition has been overemphasized by some few, but grossly neglected by the majority of physicians

E-S-I-L Bodies have not been given sufficient attention by a large number of observers to assume its rightful place in the over-all picture of the diagnosis and treatment of low-back disorders

Ries and Lifvendahl, examined 1,000 persons in dispensaries, hospitals, and other places Their first series included 250 males and 750 females Three-hundred and nine had backache in the lumbosacral region, 150 of these were without any tumors But among the 1,000 examined, 317 had tumors, a ratio of 31 7 per cent

It was found that fat patients were as often without tumors as thin ones No connection with "adiposa dolorosa" of Dercum has been established

The examination is carried out with the subject sitting on an examination table bending forward or lying on one or the other side The tips of the examiner's fingers pass over the entire sacral and iliac regions No tumors are counted as positive which cannot be moved freely No tumor is put into the category of "sensitive" unless the patient identifies the area positively on repeated palpation

Symptomatology —Patients with these painful tumors recognize the area as the seat of their pain immediately, and the pain is elicited promptly by handling, pressing or moving the tumor

In some patients pressure on the episacroiliac lipoma is not only painful, but causes pain to radiate

Location —The dimples in the regions of the posterior superior iliac spines are the usual sites of these growths Most of them are found within 5 cm of either dimple The mobility of the tumor is distinct

In most cases the masses are symmetrical and of similar shape on both sides There may be as many as four or six, arranged in vertical rows over the sacroiliac joint

Pathology —*Episacroiliac tumors are more or less rounded cylindroids* They have a distinct fibrous capsule and are smooth on the surface The cut section shows fat tissue Microscopically they consist of fat with very *little connective tissue between the fat cells while the capsule consists of* fibrous tissue A small nerve has been found running through the middle of the tumor

At operation the masses resemble a lady's powder puff saturated with olive oil and water with a few blood vessels and nerves

Treatment —The treatment of episacroiliac lipomas is injection or excision Injection of 2 per cent novocaine into the tumor or around and under is usually effective in relieving the pain The relief is strikingly rapid and the relief usually persists for days or weeks

In the case of large tumors or where injection of novocaine has relieved only temporarily, the tumor or tumors have been excised, usually under local anesthesia It is a simple matter to "peel out" the tumor from the surrounding tissue and there is very little bleeding

Treatment includes diet, endocrines diuresis and dehydration local injections, physical therapy and surgery Surgery produces dramatic relief,

by the excision of irreducible fat herniae and the removal of localized areas of painful tissue in severe cases of panniculitis. Hertz' series reached a total of 220, 68 of which he had operated upon. Hutcheson reported 12 cases operated upon.

One can anesthetize the entire area and obtain temporary relief. Repeated sessions are usually successful.

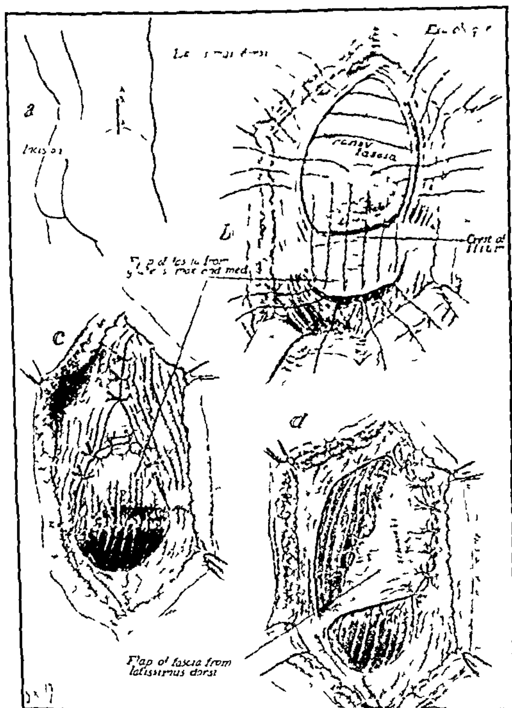


Fig. 249.—Dowd's operation for lumbar hernia. The line of incision is shown at point a. At point b a flap of fascia lata and aponeurosis of the gluteus maximus and medius muscles is turned up and sutured to the lumbar fascia and the external oblique and latissimus dorsi muscles. After the flaps are sutured a gap still remains c. This gap is closed d with a flap of fascia from the latissimus dorsi. (From Watson, *Hernia*, courtesy of C. V. Mosby Co.)

One cannot do much about the resolution or absorption of the fat However, a great deal can be done to reduce the superimposed edema which may be followed by remarkable improvements Surgery is usually very successful if it is done carefully deliberately and completely

While Ries and Lifvendahl deserve credit for describing the condition Copeman put it on a firm clinical basis and popularized it among the profession His articles are the most scientific

Twenty-two selected case histories were published by Copeman and Ackerman in 1944 and 1947 in which removal of a fat hernia resulted in a

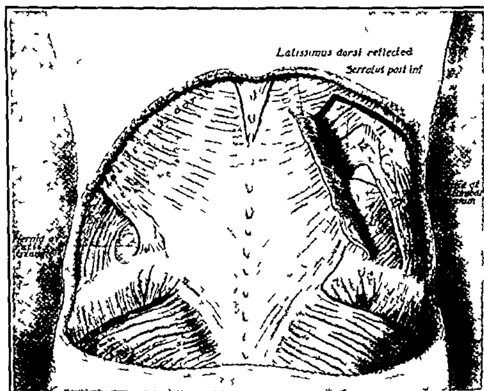


FIG 250 —The anatomic background of lumbar hernia Petit s triangle and the superior lumbar triangle are shown in relation to the surrounding structures (From Watson *Hernia* courtesy of C V Mosby Company)

permanent cure of pain Many subsequent unpublished cases have been investigated with similar findings and results

Herz reports that of 302 consecutive cases of low-back pain this type of herniation was a factor in 92 Symptoms were controlled by repeated injections Operation for removal of herniated fat was performed in 89 cases Herz marks the herniated fat with a dye before operation and blocks it off with 30 to 50 cc of 1 per cent procaine hydrochloride The skin is incised and the herniated fat excised by sharp dissection If the hernial opening cannot be located dissection is continued until deep fascia is encountered A rubber dam drain is inserted and left for one week

Surgery is resorted to in cases in which relief obtained from injection is too short or in which repeated injections are impracticable

As far back as 1925 Burbank called my attention to tender bursae in the region of the posterior superior iliac spine. Undoubtedly most of these were instances of L-S I I bodies.

LUMBAR HERNIA

A lumbar hernia may occur anywhere in the region bounded above by the twelfth rib, below by the crest of the ilium, in front by a line drawn vertically downward from the anterior extremity of the twelfth rib to the crest of the ilium, and behind by the vertebral column and the erector spinae muscles. Thorek classified lumbar hernias as (1) extraperitoneal, (2) paraperitoneal, and (3) complete intraperitoneal. Lumbar hernias may be either unilateral or bilateral. It occurs more often in the male than in the female and shows a predilection for the left side of the body. The highest incidence is among persons of middle age.

The treatment is radical operation unless definitely contraindicated. The prognosis is generally favorable.

CHAPTER 36

CONDITIONS INVOLVING THE SACRUM

Saunders and Inman localize the center of gravity of the body at the level of the second sacral segment

CONGENITAL ABSENCE OF THE SACRUM

Hamsa described 2 cases of congenital absence of the sacrum and included a synopsis of 18 cases which he found in the literature Girard found descriptions of 7 other cases, the first of which was reported by Hohl in 1852 Girard reported a case of complete absence of the sacrum and coccyx

DEVIATIONS OF THE SACRUM IN THE SAGITTAL PLANE

Albanese described 6 cases of deviation of the sacrum in the sagittal plane which has been designated as sacrum acutum and sacrum arcuatum Asymmetry of the pelvis accompanies the various deviations of the sacrum and confirms the congenital nature of the abnormality

In 2 cases there was a history of trauma that probably had increased a congenital deviation causing painful symptoms The author concluded *that there are two types congenital and acquired* The conservative treatment is physical therapy and orthopedic appliances For severe forms, a fusion operation may be indicated

Lesions involving the sacrum are congenital defect or absence, spina bifida abnormal tilt fracture dislocation spondylolisthesis, tuberculosis, osteomyelitis disk disorders and tumors

Zimmerman reported a case of an anterior dislocation of the sacrum off the lumbar spine with cauda equina injury The dislocation was reduced but much of the motor paralysis of the lower extremities was permanent

PRESACRAL TUMORS

MacCarty found that presacral tumors presented a combined problem He therefore sought the aid of three surgical specialties specialists neurologists orthopedists and general surgeon in solving some of his problems

They worked out a successful plan of surgical management and technic that *eradicates the lesion with minimal disturbance of structural and neurologic function*

MacCarty, Waugh and Coventry describe the preoperative management of presacral tumors as follows When the diagnosis of a sacral or presacral tumor is established by rectal examination neurologic evaluation and roentgenographic studies there are certain steps to be carried out preoperatively to reduce the incidence of wound infection and to prepare the lower

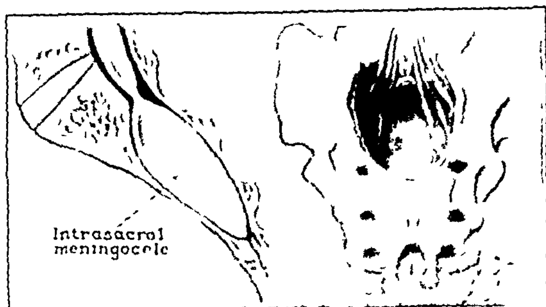


Fig. 251.—*Left.* Relationship of the intrasacral meningocele to adjacent landmarks. *Right.* Lesion has been ligated at its stalk and removed. Note the flattening and anterior displacement of sacral nerve roots. (Baker and Webb: Proc. Staff Meeting of Mayo Clinic.)

Fig. 252. Phase one in the surgical technic for removal of sacral and presacral tumors. The tumor is mobilized and dissected away from the rectum and other pelvic organs. (MacCarty, Waugh and Coventry; courtesy of Proc. Staff Meet. Mayo Clinic.)

part of the colon and the rectum for possible resection if such an eventuality is necessary Preparation of the colon usually requires three days The morning of operation the rectum is aspirated by means of a rectal tube

Penicillin and dihydrostreptomycin are administered the day before the operation and continued for five days postoperatively

Surgical Technics —Each of the three specialists plays an important role The abdominal surgeon mobilizes and protects the rectum and pelvic organs The orthopedic surgeon and the neurologic surgeon resect the tumor from the ligaments and surrounding muscles The orthopedic surgeon osteotomizes the sacrum and ilium The neurologic surgeon identifies and preserve the sacral roots, pudendal and sciatic nerves If there is intraspinal and subarachnoid extension he handles these problems

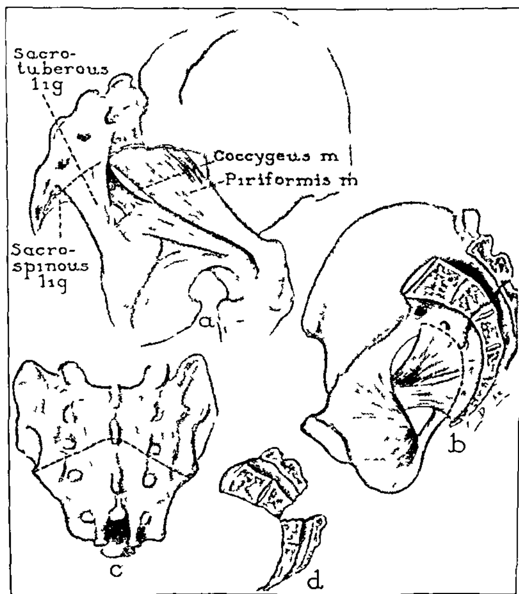


Fig 253 —This reveals the anatomic detail and method of removing the lower two or three segments of the sacrum (MacCarty Waugh and Coventry courtesy of Proc Staff Meet Mayo Clinic)

The patient is placed on the operating table face down in the Kraske position. If there is sacral erosion a needle biopsy is obtained. With the fresh frozen section technic the solid tumors can be immediately diagnosed in a high percentage of cases. If the lesion is a meningocele or a presacral abscess, this is readily established. If the tumor is malignant there is a *minimum of spreading of the tumor cells*.

An incision is made longitudinally along the sacrum extending caudally to the coccyx. The coccygeal anal ligament is divided, the coccyx is removed and the presacral mass is separated from the rectum. The gluteus muscles, sacrotuberous and sacrospinous ligaments, and piriformis and coccygeus muscles are detached.

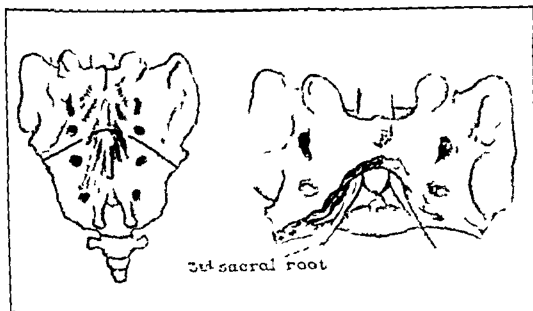


Fig 204 — This reveals the completed operation with sparing of the upper three sacral nerve roots. It also indicates how the sacral removal may be more extensive by further rongeuring the bone of the sacrum or sacro-iliac joints and still leaving these roots intact. (MacCarty, Waugh and Coventry, courtesy of Proc Staff Meet Mayo Clinic)

The lower two sacral nerves are divided bilaterally and the pudendal nerves are identified and preserved. In most cases the lower three sacral segments can be resected and the pudendal nerves including their two roots, the third and second sacral, can be spared. This is done by splitting the third sacral foramina anteriorly and posteriorly, preserving the nerves as they ascend in the sacral canal. The sacrum and tumor are then withdrawn after cutting across the sacral arch and sacral body between the second and third sacral segments and dividing the filum terminale. If the tumor extends into the upper sacral segments or lumbar canal or into the sacro-iliac joints and ilium, neurologic deficits may exist.

Occasionally a hole is made in the rectum but *repair is not difficult*. If there is a low caudal sac a spinal fluid leak might result but this is readily stopped by a suture. Because of the tremendous dead space resulting from removal of these tumors and portions of the sacrum a Penrose drain is left in the space. The gluteal muscles are resutured as firmly as possible and the subcutaneous tissues and skin are closed in a routine manner.

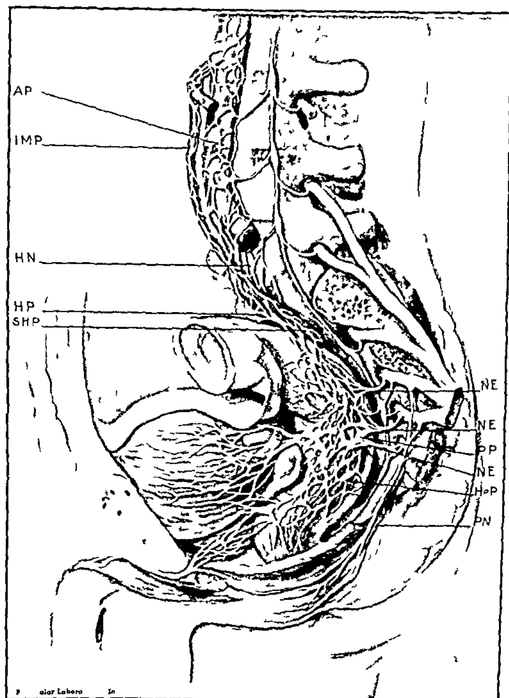


FIG 2?5 —The nerve supply of the rectum and anal canal The rectum proper is innervated by the autonomic nervous system—receiving both sympathetic and parasympathetic nerve fibers The nerve supply of the anal canal on the other hand is derived chiefly from the somatic or cerebrospinal nervous system *I M P* inferior mesenteric plexus *A P* aortic plexus *H N* hypogastric nerves *H P* hypogastric plexus *S H P* superior hemorrhoidal plexus *N E* nervi erigentes *P P* pelvic plexuses *He P* hemorrhoidal plexus *P N* pudendal nerves (Courtesy of Petrogalar Laboratories)

CHAPTER 37

THE COCCYX

The coccyx or os coccygis represents the remains of the anthropoid tail. Its function in man is to afford attachment to important muscles. The coccyx derives its name from the Greek word *Kokkyx* meaning cuckoo, based on the resemblance of the coccyx to a cuckoo's beak. Colloquially, it is called the tail bone or crupper bone.

According to Johnson, embryologists have demonstrated that in the human embryo of approximately 7 to 12 mm., there is a true tail one-sixth the length of its body.

Anatomy.—The coccyx consists of four segments joined together into a cone-shaped structure which articulates above with the sacrum forming the sacrococcygeal joint. According to Gray, the coccyx is usually formed of four rudimentary vertebræ, the number may, however, be five or three. These vertebræ contain no pedicles, laminæ or spinous processes. The last three segments are usually fused. Four important muscles are attached to the coccyx: the gluteus maximus posteriorly, the coccygeus anteriorly, the sphincter ani to the tip in front and the levator ani to the tip behind. The sacrococcygeal ligaments surround the sacrococcygeal joint. The attachments to the anterior surface are the anterior sacrococcygeal ligaments and the levatores ani and part of the rectum. The posterior surface contains a row of tubercles representing the rudimentary articular processes, the superior pair are called cornua. The borders of the coccyx are narrow and afford attachment on either side for the sacrotuberous and sacrospinous ligaments, to the coccygeus muscles in front of the ligaments and to the gluteus maximus behind them. The apex affords attachment to the tendon of the sphincter ani externus.

The coccyx is ossified from four centers, one for each segment. The nuclei make their appearance in the following order: in the 1st segment from the first to the fourth year; in the 2d from the fifth to the tenth; in the 3d, between the tenth and fifteenth; in the 4th between the fourteenth and twentieth. Union between the 1st and 2d segments is frequently delayed until the age of twenty-five to thirty. At a late period in life, especially in females, the coccyx often fuses with the sacrum.

The coccygeus muscle is situated behind the levator ani. It is a triangular sheet of muscular and tendinous fibers arising by its apex from the spine of the ischium and sacrospinous ligaments and inserted by its base into the margin of the coccyx and into the side of the lowest portion of the sacrum. It is supplied by a branch from the 4th and 5th sacral nerves. The levatores ani and the coccygei together form a muscular diaphragm which supports the pelvic viscera. The coccygeal branches of the inferior gluteal artery run medialward, pierce the sacrotuberous liga-

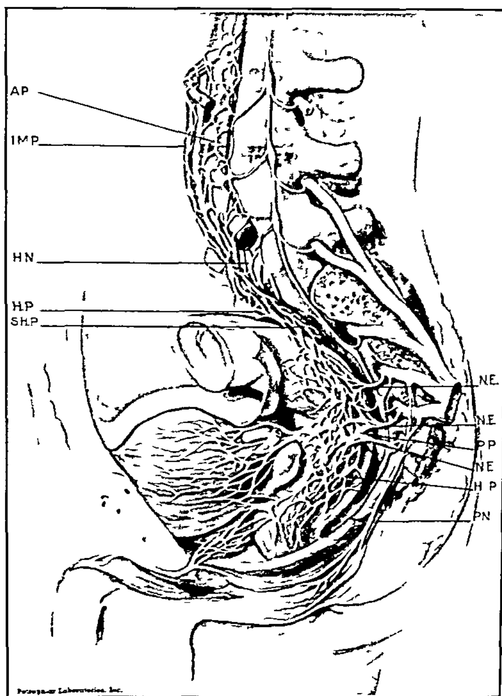


FIG 255 —The nerve supply of the rectum and anal canal The rectum proper is innervated by the autonomic nervous system—receiving both sympathetic and parasympathetic nerve fibers The nerve supply of the anal canal on the other hand is derived chiefly from the somatic or cerebrospinal nervous system *I M P* inferior mesenteric plexus *A P* aortic plexus *H N* hypogastric nerves *H P* hypogastric plexus *S H P* superior hemorrhoidal plexus *N E* nervi erigentes *P P* pelvic plexuses *He P* hemorrhoidal plexus *P N* pudendal nerves (Courtesy of Petrogalar Laboratories)

of the first sacral afferent elements, that the most common site of the primary source of the pain consists of soft-tissue structures probably fat tissue in the mid sacral region

From a survey of different features seen in connection with coccygodynia, the functional element is considered to be important It is possible to find a neurotic background in patients so afflicted Both the psychic manifestations, when present, and the coccygeal pain are direct results of the primary source of pain in the fat tissue

The superior gluteal nerve may be compressed against the lower border of the gluteus medius

Such pain is caused by pressure of an associated spastic piriformis muscle on the sciatic nerve as it emerges through the sacrosciatic foramen, and upon the superior gluteal nerve as it passes between the upper border of the spastic piriformis and the lower border of the gluteus medius

Symptoms —The chief symptom is localized pain The history is usually that of a fall and forcible sitting down, or of a blow or kick It occurs more frequently in females, many of whom are neurotic Symptoms of "dislocation" of the coccyx are pain or coccygodynia, especially on sitting Patients complain of their inability to sit for more than a brief period Their discomfort is usually more marked when the seat is soft Pain may be felt on defecation, especially if the patient has intestinal stasis Paresthesia may be present

Fractures of the coccyx are due to direct injuries, from a fall on the buttocks or direct blows or kicks The symptoms are pain while sitting or defecating tenderness, swelling and ecchymosis

History —Some of the patients complain of pain in the "tail-bone"

If sudden trauma has been the causative factor, muscle spasm occurs at once and the onset of pain and tenderness is sudden

The severity of the pain is in direct proportion to the length of time that sitting is continued without interruption but is most severe during the act of arising from that position

The average patient is more uncomfortable when sitting in an upholstered chair in poor posture than when sitting on a hard chair in good posture

Coccygodynia —Coccygodynia means pain in the coccyx and neighboring regions According to Newman and Berris pain is present about the coccyx and superior gluteal region and even along the course of the sciatic nerve Krusen and Bason found that in the presence of coccygodynia the local region is painful, often because of spasm of the levator ani the coccygeus and piriformis muscles Coccygodynia of this type is commonly mistaken for coccygeal injury, sciatic neuritis intrapelvic lesions or lumbago

The pain is aggravated by continued sitting and accentuated by arising to a standing position owing to the added contractions of the levator muscles and probably the inner gluteal fibers with constant, increased traction on the coccyx, thereby producing stress on the sacrococcygeal joint

In about 85 per cent of the patients the pain is either in the sacrococcygeal joint or in the muscles which are inserted into the lateral borders of the coccyx These muscles are the levator ani, the coccygeus and a bundle of fibers from the gluteus maximus

ments and supply the gluteus maximus muscle, the skin and other structures on the back of the coccyx

The posterior division of the coccygeal nerve receives a communicating branch from the last sacral nerve It is distributed to the skin over the back of the coccyx The anterior division of the coccygeal nerve curves forward below the rudimentary transverse process of the first portion of the coccyx The coccygeal plexus is formed by the 5th sacral nerve a communicating branch from the 4th and the coccygeal nerve The coccygeal body or gland, called the glomus coccygeum, or Luschka s gland, is in front of or immediately below the tip of the coccyx It is about 2 5 mm in diameter

DISTURBANCES OF THE COCCYX

The chief affections of the coccyx are contusion, fracture, dislocation hernia and neoplasms The most important clinical disturbances of the coccyx are 'dislocation' ankylosis at the sacrococcygeal articulation tumors and disease, the first of which is most important A condition called coccyx arcuatus has been described

Etiological Factors —The chief causes of coccygeal disturbances are direct injuries

Painful coccyx is usually due to a fall with the person landing in the sitting position A common occurrence is a fall while walking downstairs when a person is carrying a large breakable object in each hand

Coccygodynia is caused by direct trauma and by secondary muscle spasm

Trauma is the most frequent cause of discomfort Coccygodynia is more common in women than in men Haggart and Schuler describe the female sacrum as shorter and wider and has less of a forward curve than the male, moreover the ischial tuberosities of women are wider apart the coccyx is usually more movable and hence more vulnerable to injury

Prolonged automobile rides and continued poor posture may be a contributory factor

In Thiele s opinion coccygodynia is due to three factors

1 Direct trauma

2 Continued immobilization of any joint maintained in a position of flexion by muscle tension will cause pain in that joint In coccygodynia the sacrococcygeal joint is maintained in a state of constant flexion by tension of the spastic levator ani and coccygeus muscles

3 Muscle spasm itself may be painful Repeated or sustained muscle contraction results in the formation of lactic acid which first causes fatigue and then pain Anoxia may also be a factor

Any focus of infection the lymphatic drainage from which is toward the pelvic muscles, may cause myositis or reflex spasm of those muscles resulting in coccygodynia

Parturition, bumps against furniture and kicks by human beings are other etiological factors

Dittrich finds that the bony portion of the coccyx probably lies within the first sacral sclerotome, that coccygodynia may arise and persist as referred pain from a trigger point located elsewhere within the distribution

Sir James Y. Simpson stated when the coccyx or coccygeal joints have been injured or when the surrounding structures were the seat of inflammation, any contraction of the muscles connected with the coccyx would excite the characteristic pain of coccygodynia.

Any contraction of these muscles such as in walking, sitting down or arising from a sitting position would move the sacrococcygeal joint. He attributed pain during defecation to the contraction of the levatores ani. Simpson's basic conceptions of coccygodynia were entirely correct. There may be an accompanying posterior urethritis, prostatitis, seminal vesiculitis, bladder irritability or a purulent vaginal discharge.

Physical Examination.—Mobility of the coccyx is in itself not a sign of dislocation or fracture. If movement causes pain it is significant.

Insert the gloved finger full length into the rectum, place the thumb over the coccyx externally and palpate the coccyx between the thumb and finger. Move the finger laterallly from the posterior midline. Move the finger laterally, anteriorly and then medially describing an arc of 180 degrees until the finger lies just posterior to the symphysis pubis. Muscle tenderness and spasm are noted.

Digital probing of the coccyx and adjacent soft parts, visualization of the anal ring and the canal immediately above, and proctoscopic examination for 10 inches above the sphincter are indicated for all patients with pain in the coccyx area. Rectal examination yields valuable information. Roentgenograms usually do not reveal the lesion completely. In one of my patients the coccyx was shattered into eight pieces. I removed them completely, with a perfect result.

Roentgenograms may reveal malalignment of the coccyx but do not often show any demonstrable changes, compelling the surgeon to rely on the history and especially the rectal examination.

Diagnosis.—Rectal examination is most valuable. With the patient lying on the left side with knees and hips flexed, the examiner's right index finger, gloved and covered with petrolatum, is inserted into the rectum, the thumb being placed over the coccyx, outside that structure. If there is abnormal mobility at the sacrococcygeal articulation with accompanying sensitiveness and tenderness, the diagnosis is conclusive. If the examiner can reproduce the pain complained of, it is very good evidence.

The diagnosis of coccygodynia is based on the following factors: pain in the region of the coccyx and lower portion of the sacrum and in the adjacent muscles and soft tissues. Coccygodynia is definitely and characteristically aggravated by continued improper sitting. It is characteristically most severe during the act of arising from the sitting position. Tenderness on pressure against the tip of the coccyx is present in cases of recent traumatic origin but in those cases in which muscle spasm has resulted from chronic focal infection, pressure against the coccygeal tip usually does not increase the pain. The spastic muscles are invariably tender.

The differential diagnosis includes fracture-dislocation, contusion, tuberculosis, osteomyelitis and neoplasm. A few other lesions may localize pain in the coccygeal area, but a careful physical examination will *differentiate* them.

Tuberculosis of the coccyx has been reported, and tumors may be found in this region. Sicard described condensing osteitis of the coccyx.

The coccygeal region may be tender, and tonic spasm and tenderness of the levator ani, coccygeus and pyriformis muscles may be present There may be sciatic and suprагluteal tenderness at times causing the patient to walk stiffly and to sit on one buttock Pain in the coccyx and suprагluteal region extending down the back of the thigh, is worse when the patient is sitting and is relieved when he lies on his side

A vicious cycle consists of pain, muscle spasm more pain, more spasm

The pain is due to local injury of the coccyx and its surrounding soft parts Duncan sought to demonstrate the coccyx as much more prominent posteriorly in the female pelvis and hence more liable to injury The location of the pain is such that not only is it uncomfortable to the patient but she may neglect the condition for many weeks, as she may be loath to discuss such a disorder with her physician

Hirschman recommended more attention to coccygodynia, since it is often caused by a true arthritis of the sacrococcygeal joint possibly due to an infected anal crypt

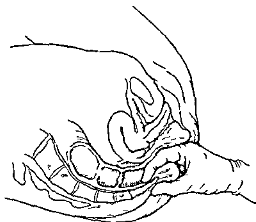


Fig 256 —Rectal examination and manipulation of coccyx Patient lies on left side with knees and hips flexed Examiner s right index finger in rectum and thumb outside

Sacrococcygeal contusion usually is due to a fall during which the patient lands in a sitting position It is also found after an object strikes this region Kicks in this region may be serious I had a patient who was sitting on a low stool on the floor when her husband in jest, kicked her and injured the sacrococcygeal region

Osteitis and osteomyelitis of the coccyx are rare Blount reported a case of osteomyelitis cured by resection

Suermont described a type of coccygodynia which occurs almost exclusively in women It is a severe neuralgia of the nerve plexus which winds around the sides of the coccyx It may be caused by fractures dislocations and osteomyelitis but in many cases occurs spontaneously Some neurologists consider the condition is a type of vaginismus and recommend psychoanalysis Others advise resection of the coccyx Suermont advised caudal epidural injections of 40 cc of 1 per cent solution of novocaine Alexander stated that a vaginal examination will often reveal a hematoma

Pain in the coccyx is rarely of psychic origin though neurasthenia may develop secondary to prolonged and severe pain

Application of radiant heat or diathermy and massage to the lower part of the back, coccygeal region and gluteal muscles may afford relief from pain. This should be followed by a special type of internal massage according to the technic described by Newman and Berris and by Thiele. Insert the full length of a finger into the rectum with its flexor surface across the levator ani and coccygeus muscles and its tip on the piriformis muscle. Massage in the direction of the long fibers as a strop is stroked by a razor. Massage lightly at first increasing the pressure at subsequent treatments. Thiele has reported that 60 per cent of his patients were cured, and 33.7 per cent definitely improved. If improvement did not take place after four or six daily treatments, he advised orthopedic or other consultation. Thiele and eight associated proctologists treated 80 patients by this method noting cure in 60 per cent, improvement in 33 per cent and failure in 6.3 per cent of cases.

Haggart and Schuler advised massage of the spastic muscles together with removal of any foci of infection. In cases of osteoporosis, osteomyelitis or fracture, coccygectomy may be necessary.

Patients are given a posture training program under supervision of an expert physical therapist with particular reference to the development and function of the gluteal musculature. By this means the patient's general body mechanics improve, the pelvis is tilted backward and so that the coccyx moves forward and is less exposed to repeated trauma.

The patient is instructed to sit on a straight-back chair with a hard seat and wedged cushion, with the thick end toward the knees. Thus the weight of the body is on the under side of the thighs and the coccyx is freed from pressure.

Overstuffed chairs should be avoided. Thiele recommended the treatment of coccygodynia by massage of the levator ani and coccygeus muscles. Of 169 patients there were 27 males and 142 females.

Sedatives, antineuritics and antispasmodics and the use of counterirritants, rectal suppositories, hot applications, cold applications, electrotherapy, massage of the coccyx, injection of local anesthetics, x-ray therapy and coccygectomy may be required.

If non-operative measures give only partial or no relief, the coccyx should be removed. As a medical student I was warned, "Never do a coccygectomy on a nervous woman." My question is, How can a woman have coccygodynia without getting nervous?

SURGERY

For the operative removal the patient should be placed on the table prone so that the lower end of the table can be dropped and with it the lower extremities. The buttocks are held apart with wide strips of adhesive applied to the buttocks and secured to the operating table (Fig. 257). A midline incision is made in the median raphe. With an assistant's finger constantly in the rectum as a guide, a careful submuscular dissection is made and the coccyx is removed at the sacrococcygeal joint. All prominent bone structures are rounded off. Key resects the lower half inch of the sacrum. A purse-string suture is then inserted. Two or three deep, and as

Other conditions that must be differentiated are neurosis, neuritis, neuralgia, rheumatism, sprain, luxation and fracture

Pilonidal inflammation and anorectal disease must be differentiated

Prognosis —The operative relief in selected cases of coccyx disturbance should be constant A nervous disposition may jeopardize a good result, but on the other hand psychotherapy may fail unless surgery is performed Many patients with coccygodynia have arthritis of the lumbo-sacro iliac region and it is important to explain that removal of the coccyx will not cure the arthritis higher up In some patients, the pain complained of is due to a pathological condition which owing to proximity of a sensitive plexus of nerve groups is irritated by trauma the patient becoming nervous and irritable Patients of this class respond well to surgical measures

Thiele strongly questions the value of coccygectomy as a cure for coccygodynia In 5 of the 6 patients in whom there was no improvement, lawsuits were pending against department stores where injurious falls were alleged to have occurred

Treatment —Non-operative pain at the tip of the spine can usually be relieved by conservative measures In the acute phase patients are directed to take hot sitz baths four times a day, less often as the symptoms subside

For refractory cases and those of traumatic origin seen immediately after injury manipulation and massage, performed three times weekly with anesthesia, are effective in relieving pain The patient lies on the side with hips and knees sharply flexed

Massage is performed with the gloved fingers directly over the coccyx and lower sacrum, the fingers sweeping laterally to either side of the bone Manipulation is effected by grasping the coccyx with the forefinger and thumb and applying traction as the bone is moved on the sacrum The number of treatments weekly is gradually decreased as symptoms improve Massage of the spastic muscles attached to the sides of the coccyx may be helpful A stropping motion (like sharpening a razor) is employed

Treatment includes hot sitz baths sitting on rubber rings and strapping of the pelvis Wearing of a corset and rest should be mentioned as well as back massage If these are unsuccessful operation is indicated One must not overlook the problem of arthritis If trauma has not produced the condition, one should try to avoid operation

Repeated massage may be given through the rectum with or without anesthesia For acute painful conditions salicylates by rectum may be helpful

The most common lesions that respond favorably to manipulation are dislocation fracture and adhesions

There are cases of injury to the coccyx with deflexion followed by adhesions and possibly arthritis The treatment should be non operative for a reasonable period Under gas and ether anesthesia manipulation is sometimes successful in correcting dislocations and breaking down adhesions preferably immediately after injury The patient should lie on his left side with knees and thighs flexed With the right index finger in the rectum, the coccyx can be accurately manipulated and its alignment adjusted After manipulation an opium suppository may be introduced and the buttocks strapped together with adhesive

from the lateral portion of the lower sacral and coccygeal vertebrae and the posterior aspect of the sacrotuberous ligament. These attachments blend with the superficial and deep layers of the supraspinous ligament, the superficial sacrococcygeal ligaments and the deep posterior longitudinal ligament of the spine, which provide an exceptionally strong fibrous support to the pericoccygeal region. Between the tip of the coccyx and the anus lies the fibrous raphe of the iliococcygei and beneath this the aponeurosis of the pubococcygeus muscle. On the deep surface of the levator ani, the endopelvic fascia and the uterococcygeal or prostatococcygeal ligaments blend with the anterior sacrococcygeus muscles and ligaments. For a hernia to appear in this area some loss of substance, following either operation or severe trauma, is necessary.

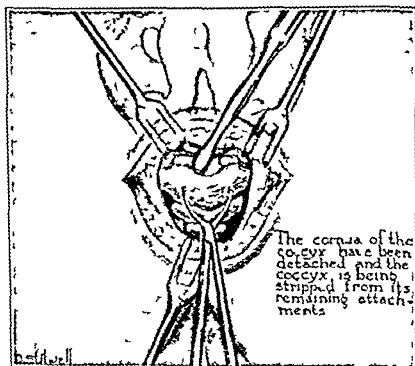


Fig. 258. Coccygectomy. (Steindler, courtesy of C. C. Thomas.)

Nichols and Herring have been able to find only 1 case of coccygeal hernia. Pagenstecher's patient was a white woman who suffered a fracture of the coccyx during parturition twenty-seven years prior to surgical removal of the coccyx for relief of pain. Seven months later she returned, complaining of pain, inability to sit in comfort, the development of a mass and the sense of sitting on her bowels. She was treated by excision of a sac the size of an orange and approximation of adjacent muscle and fibrous tissue with chromic catgut. *The final result was satisfactory.*

Human Tails.—Many fantastic stories have appeared describing human beings with tails. Some reports claim the caudal appendages were 10 to 12 inches long and were covered with hair. These are continuations of the spine. They may resemble the tails of pigs or monkeys. Naturally the treatment is surgical.

many superficial silkworm sutures and a collodion-gauze dressing complete the operation

Sacrococcygeal Chordoma —A chordoma arises from remnants or "rests" of the embryonic notochord According to Fletcher, Woltman and Adson, it is found almost exclusively in two locations, the clivus Blumenbachii and the sacrococcygeal region In the latter place the tumor may arise in the sacrum and remain there for the most part, it may then grow into the pelvis, with the formation of a presacral tumor or grow posteriorly, giving rise to a postsacral tumor The sites of origin are the noto

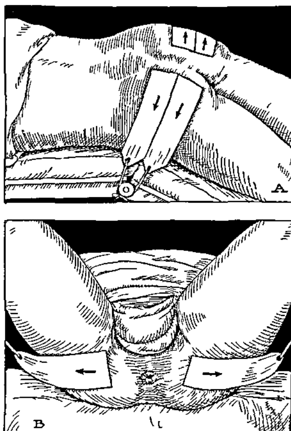


FIG 257 —Adhesive plaster distraction of buttocks to facilitate coccyx operations (Courtesy of Johnson & Johnson)

chordal remnants found normally in the nuclei pulposi of the sacrum or possibly in heterotopic foci of chordal tissue, anterior or posterior to the sacrum

Coccygeal Hernia —The rarity of coccygeal hernia is understandable according to Nichols and Herring when the density of the anatomical structures involved is considered The supporting mechanisms of the pelvic and anal diaphragms and their associated ligaments practically preclude the occurrence of hernia in the anococcygeal area In the main, the structures to be considered are the gluteus maximus muscles and their investing sheaths of fasciae latae which lie beneath the skin and the two layers of the superficial fascia In this region the gluteus maximus arises

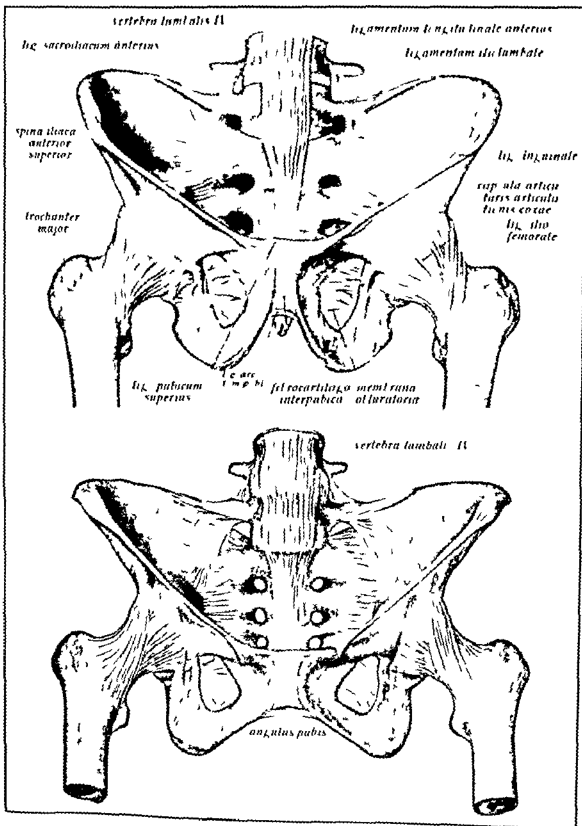


Fig. 259 Bones of the pelvis

CHAPTER 38

THE PELVIS

THE pelvis is a strong broad ring of bone which supports the spine and transmits the weight of the rest of the body to the lower extremities It also supports and offers considerable protection to the abdominal and pelvic viscera and serves as points of attachment for muscles which move the lower extremities and trunk It is composed of the two innominate bones, which are united in front at the symphysis and the sacrum, which closes the ring behind and articulates with the innominate bones at the sacroiliac joints

The pelvis is so formed that by the use of arches of strong bone it is enabled to support the body weight and resist shocks and blows on all sides Morris's Anatomy has pointed out that the pelvis consists of two main arches and that the sacrum is the keystone of both of them The femorosacral arch extends from the acetabula upward through the thick portions of the iliac bones, to the sacrum, to support the body weight in the erect position and the ischiosacral arch extends upward from the tuberosities through the bodies of the ischia, and the thick portion of the ilia to the sacrum to support the body weight when sitting

In addition to the two main arches there are two tie arches which prevent the main arches from spreading The horizontal rami and bodies of the pubis support the femoro-sacral arch and the united rami of the ischium and pubis support the ischiosacral arch

One of the most important questions is "Is the patient's pelvis in balance?

The pelvis must be in balance during standing and walking or the person will get into trouble sooner or later

Pelvic imbalance is easily determined by the

1 Standing test

2 Kneeling test The patient is instructed to kneel on the examining table This usually determines whether the shortening is above or below the knee Kneeling usually eliminates pelvic obliquity

FRACTURES OF THE PELVIC BONES

Fractures of the pelvis are greatly on the increase resulting mainly from automobile injuries and similar forms of transportation A plea for conservatism in the treatment of fractures is emphasized by Conwell as well as early reduction By so doing major surgical procedures are often prevented as well as are more serious complications Only in rare cases is it necessary to do open operative procedures on pelvic fractures provided the above precautions, and good surgical judgment and technic, are carried out

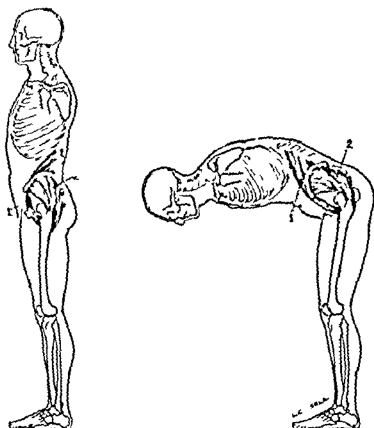


FIG 261 —Diagrams of skeletal muscles 1 Iliopsoas 2 gluteus maximus (Redrawn from R C Mackenzie The Action of Muscles reproduced by permission H K Lewis & Co Ltd London)

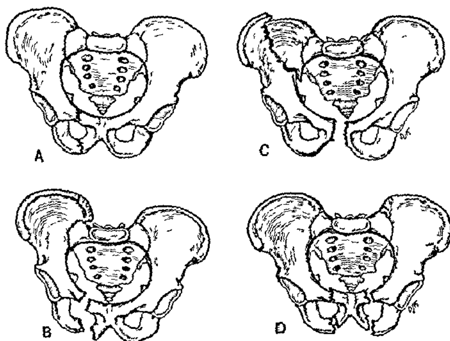


FIG 262 A Injury of the pelvic ring B and C Combined injuries of the pubic and iliac segments of the pelvic ring produced by antero-posterior compression There is severe displacement patients must lie on their side D Combined injury of the pubic segment of the pelvic ring produced by lateral compression There is moderate displacement patients must lie on their backs (R Watson-Jones courtesy of the British Jour Surg)

The pelvis is motivated by the movements of the legs and trunk

Clinically most fractures of the pelvic ring occur in the anterior portion (tie arches), and the posterior portion (main arches) is rarely broken without there being also a fracture of the anterior portion

Many fractures of the pelvis are never diagnosed because they frequently occur in conjunction with other fatal injuries such as result from falls from a great height, in mining railroad or automobile accidents

Most fractures of the pelvis are caused by direct trauma such as heavy blows or severe crushing injuries When the force is applied in the antero posterior direction the front of the pelvic ring (one or both rami) usually

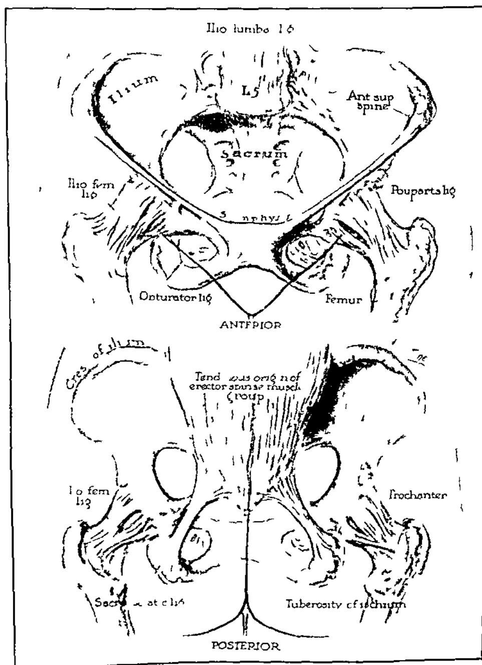


Fig 200 —Pelvic ligaments (Courtesy of S H Camp and Co)

FIRST AID IN INJURIES TO THE PELVIS

Considerations
- I Prevent further injury
- II Determine severity of injury
- III Rule out serious lesions urethral injury—bladder injury
- IV Relieve pain
- V Support
- VI Transport

Importance
- Civilian
- Athletic
- Industrial—occupational
- Military

Cardinal Considerations
- I Avoid further injury
- II Save life
- III Combat shock
- IV Control hemorrhage
- V Relieve pain
- VI Avoid infection

If the pelvis is fractured the two essentials are to treat shock but do not move the person until adequate assistance is available

There is pain, unless shock is too severe It hurts to move, it hurts more to sit up There may be numbness of one or both legs The lumbar spine may be injured by the same force that fractured the pelvis If the bladder is punctured or ruptured there is severe pain in the lower part of the abdomen the shock is greater and the urine is bloody

The person should be gently stretched out flat, kept warm and given a drink of anything except liquor The pelvis can be supported by strapping snugly with one or two belts

A scultetus binder is very useful If adhesive is used the injured person should not be turned too much or twisted He must not be lifted into a sitting position as a jagged piece of bone inside may pierce the bladder, injure the bowel or rupture a large blood vessel

Fractures of the pelvis have been divided by Watson Jones into injuries not involving the pelvic ring (fractures of the crest and spines of the ilium, of the acetabulum and of the sacrum and coccyx) and those involving the pelvic ring

Isolated fractures of the pelvic ring are treated by simple recumbency, the patient may lie in any position

Combined fractures of the pubic segment of the pelvic ring are produced by lateral compression of the pelvis They are treated by simple recumbency the patient must lie on his back and not on one side

Combined fractures of the iliac and pubic segments of the pelvis cause complete disruption and wide displacement They are produced by antero posterior compression of the pelvis The displacement is most easily corrected by manipulation in lateral recumbency and the application of a double plaster spica The patient must lie on one side and not on his back

breaks first, and then if the force continues to act, the strong main arch is spread and the posterior portion of the ring is broken near the sacroiliac joint, usually on the same side as the fracture of the anterior arch With lateral force, the same type of injury tends to occur, but the anterior ring is broken by being forced inward In a fall upon the feet, with the force acting from below upward, the same sequence of fractures may occur

One of the most common severe complicated types of pelvic fractures is the double vertical fracture of Malgaigne Other fractures of comparative severity are multiple fractures of the pelvis involving the lower halves causing ruptures of the bladder, perineum, and deep urethra

The relatively high mortality in fractures of the pelvis (16 per cent in Noland and Conwell's 1933 series of 185 cases) is due to the complications and associated injuries which are so frequent in these lesions In those cases that die within the first twenty-four hours after admission, death is usually cased by crushing injuries of the abdomen and pelvis, with rupture of viscera and surgical shock, or by fractures of the skull or chest

Roentgenography of the Pelvis —In addition to routine antero posterior and lateral projections, stereoscopic and oblique views, it is advisable to determine the presence or absence of abnormal excursion at the symphysis pubis The technic is to have the patient stand on one foot, then on the other The normal excursion in men is 0 5 cm , in women it ranges up to 1 5 cm

Fractures about the ischial tuberosity and acetabulum are easily over looked and often underestimated from the conventional stereoscopic antero-posterior views of the pelvis oblique projections of each side of the pelvis will show the involved areas more clearly Persistent epiphyses are occasionally present along the margins of the pubic bones (at the symphysis) and at the upper margins of the acetabula, these may be dis tinguished from fractures usually by their smooth margins and by the absence of changes after an interval of weeks

The increase in fractures of the pelvis is attributed to the more general use of automobiles busses and trucks, and the lack of respect on the part of the public for traffic laws and regulations The reports from the military surgeons have not yet appeared Multiple fractures occur more often than a single fracture

Rankin* tabulated the causes of fractures of the pelvis observed at four hospitals as follows

	Jefferson	*Pennsylvania*	*Delaware Co*	*Presbyterian*
Automobile	16	30	40	63
Collision 2 cars	3	7	18	25
Collision car and trolley	1		3	3
Pedestrian hit by automobile	8	22	14	29
Collision of car and object	2	1	5	6
Collision of automobile and train	1			
Industrial	30	46	17	38
Falls	20	17	8	19
Horse kicks	1			2
Trains	1			9
Wagon	2		1	
Elevator	3	3		
Automobile accident	2	2	5	2
Wagon	1			
Miscellaneous	20	64	5	38

* Rankin L M Annals of Surgery 106 266 1937

consists of traction on the lower extremities, with the addition of some form of pelvic sling The one described by Noland and Conwell seems to be the best Relief is immediate when extension and the hammock are applied The latter authors operated in 7 cases on 2 for internal injury and hemorrhage 1 for ruptured bladder, 1 for ruptured urethra

Fractures of the pelvis are among the serious, long-drawn-out and disabling forms of injury—disabling, because of the accompanying injury to the legs, back and pelvis, because of extension to legs and because of continued pressure on the back from being bedridden By starting physical therapy early, Rankin not only shortened the hospital stay and the total period of disability, but made this period more comfortable Economically, it means a saving to the patient, the hospital, the industrial and liability

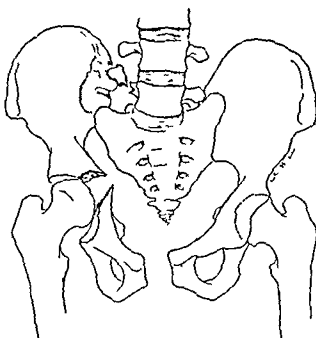


Fig 264 —Dislocation of symphysis pubis and right sacro-iliac joint with central fracture of right acetabulum The right transverse process of the 5th lumbar vertebra is broken off (Redrawn from roentgenogram)

insurance companies and the employer Extension to the legs with overhead suspended hammock and spreader, is the treatment of choice

Genito urinary tract injuries and complications were rare in this series

The death rate is low, 40 out of 449 cases Two-thirds of patients stated they were cured six months or more after their injury The chief disabling symptom was pain either in the legs or back About 10 per cent had some permanent shortening of the right leg, 14 per cent, of the left leg Under traction this percentage can be lowered Total disability in the absence of complications averaged 16 4 weeks the average period before resumption of regular work was 23 6 weeks Physical findings are more important than reports of the roentgenologists in determining when one can begin to get these patients out of bed and walking or discharge them from the hospital

The functional result depends on the accuracy of reduction of the sacroiliac dislocation, which may easily be overlooked

Pelvic fractures were classified by Noland into three groups (1) single fractures, in which the continuity of the weight-bearing ring is preserved, (2) multiple displaced fractures, *in which it is necessary to relieve the* bearing of weight until consolidation occurs and (3) double vertical fractures (Malgaigne's fracture), in which there is usually extensive dislocation of the whole pelvis

After intraperitoneal rupture of the bladder, little, if any, urine will be secured by catheter Many methods have been suggested for quick diagnosis in these cases, ranging from the instillation of sterile fluid into the bladder and its withdrawal, to decide on leakage, to the injection of an opaque substance followed by roentgen study Practically, however, it is

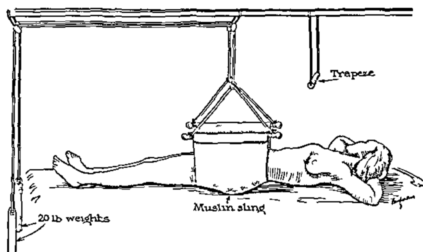


Fig 263 —Use of muslin sling suspension for pelvic fractures (After Abramson Roberts and Wilson courtesy of Surg Gynec and Obst)

generally best to wait for several hours Then, the catheter shows practically no urine, and if there is additional evidence of peritoneal invasion the diagnosis is plain and little damage has been caused by waiting If the general condition of the patient permits laparotomy and intraperitoneal suture of the bladder should be done, supplemented of course, by constant drainage over a period of days

Suspension is obtained with a canvas sling or hammock extending from the upper third of the thighs to the lower thoracic region This hammock effects immobilization because of the lateral compression on the pelvic girdle The suspending force approximately equal to the body weight, is continually in effect and as relaxation of the muscles takes place, there is a constant tendency for the displaced fragments to fall into natural position Generally marked relief of pain is noticeable within the first few hours following the application of the pelvic hammock

Rankin listed thirteen forms of treatment Rest in bed (with or without sandbags) ranked first some form of a pelvic sling or binder with some extension was second His opinion which has been upheld by Conway,

Metz Operation.—Metz applied Parham-Martin bands around and through the obturator foramina, thereby stabilizing the entire pubic area of the pelvis. Permanent adduction deformity of a lower extremity in a female presents a serious sociological and psychological problem.

PELVIC OBLIQUITY

The three outstanding authorities on the subject of pelvic imbalance and obliquity are Mayer, Lowman and Irwin.

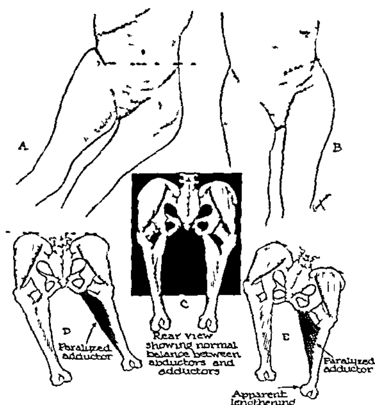


FIG 265.—Pelvic obliquity. *A*. When the pelvis is squared the right leg is abducted 35 degrees, the left leg adducted 35 degrees. *B*. The legs can be brought parallel to the vertical axis of the body only by tilting the left side of the pelvis upward 3 inches. *C*. Diagram to illustrate the relation of the femora to the pelvis in an individual whose abductors and adductors are evenly balanced. *D*. Diagram to illustrate the relation of the femora to the pelvis in an individual whose adductors are paralyzed. The unopposed abductors draw the leg outward and an abduction contracture ensues. *E*. Diagram to illustrate the final step in the development of a fixed pelvic obliquity in an individual whose adductor paralysis has resulted in an abduction contracture. To bring the abducted leg into a vertical position, the pelvis must be tilted downward on that side, thus causing an apparent lengthening of the leg. (Redrawn from Leo Mayer, J. Bone and Joint Surg.)

Mayer observed that a fixed pelvic obliquity may be caused by contracture of the spinal muscles, of the abductor or adductor muscles about the hip, or a combination of these. Irwin has recently written on the same subject. Certain cases of pelvic obliquity, arising from contracture of the abductor group of muscles of the hip with a distinct lowering of the pelvic crest and subsequent curvature of the spine, have been noted in this study. This spinal curvature becomes obvious when the limbs are placed in a parallel position, the attitude assumed in weight-bearing.

Physical therapy is a valuable adjunct in the treatment of pelvic fractures and should be started as soon as feasible The chief objective is to give massage and preserve movement in the legs and back Otherwise the patient may be disabled from long disuse of the legs Unless there are contraindications, physical therapy should be cautiously given within a few days of admission, *i e*, after the patient has had extension applied and the hammock sling adjusted

Fracture of the Anterior Superior Spine of the Ilium —Up to 1924, Carp collected 21 cases (including his own) of fracture of the anterior superior spine of the ilium The etiology of muscular avulsion of the anterior superior spine is of interest In Christopher's case it is not improbable that the muscles, which had not previously been "warmed up" by a little running, were less elastic and hence may have produced a more violent pull on the bony attachment If this is a factor in this accident, it would seem wise for coaches to insist on preliminary "warming up" before permitting young athletes in the epiphyseal stage, to engage in sprints or hurdle races

Internal Fixation for Fractures of the Pelvis —In two types of pelvic injuries—fractures of the iliac wing and separation of the symphysis pubis —internal fixation with stainless-steel pins has given satisfactory results

Separation of Symphysis Pubis —Reis, Baer Arens and Stewart found that separation of the symphysis pubis during spontaneous labor is due to "marked intensity of the uterine contractions and marked rapidity of labor" Multiparity and relative disproportion of fetus and maternal passages are additional etiological factors The separation is a result of a wedge effect produced by the violent thrust of the fetal head through the superior strait Pain is the initial and the predominating symptoms The characteristic waddling gait and the roentgenogram are diagnostic The physical findings are edema swelling tenderness pain on pressure and the waddling gait Obstetrical separation of the symphysis pubis is an uncommon cause of chronic complaints Treatment consists in pelvic immobilization which can be achieved by sandbags adhesive tape, or circular compression by pulley weight, or open operation

Traumatic separations of the symphysis pubis and of the sacro iliac joints are occasionally seen in roentgenograms The normal width of the symphysis pubis and of the sacro iliac joints is variable By suitable variations of target and object-film distance or by examination with the patient first prone and then supine one may make these joints look wide or narrow, therefore one must be hesitant in making a diagnosis of slight traumatic widening The symphysis pubis is normally several millimeters wider after parturition, and the sacro-iliac joints occasionally show a similar change Slight variations in the level of one pubic bone relative to its fellow are common Roentgen evidence of true traumatic sacro iliac subluxation (slip) is occasionally seen after violence to the pelvis and is usually associated with extensive fractures of the pelvic girdle It is impossible to diagnose mild subluxation or slip by roentgen means Technical methods have been developed to demonstrate slight rotatory motion of one or both sacro-iliac joints However there is no satisfactory clinical correlation between the demonstration of such motion at a joint and the presence of symptoms referable to that joint Therefore, a roentgen diagnosis of slight or mild sacro-iliac slip can rarely be made

Metz Operation Metz applied Putti... fascia lata around and through the obturator foramen thereby stabilizing the entire pubic area of the pelvis. Permanent adduction deformity of a lower extremity in a female presents a serious sociological and psychological problem.

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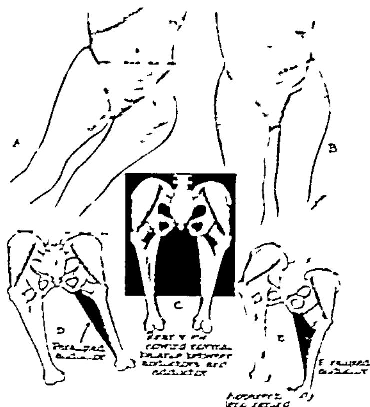


FIG. -6. —Pelvic obliquity. *A*, When the pelvis is squared the right leg is abducted 2. degrees the left leg adducted 2. degrees. *B*, The legs can be brought parallel to the vertical axis of the body only by tilting the left side of the pelvis upward 2 inches. *C*, Diagram to illustrate the relation of the femora to the pelvis in an individual whose abductors and adductors are evenly balanced. *D*, Diagram to illustrate the relation of the femora to the pelvis in an individual whose adductors are paralyzed. The unopposed abductors draw the leg outward and an abduction contracture ensues. *E*, Diagram to illustrate the final step in the development of a fixed pelvic obliquity ... an individual whose adductor paralysis has resulted in an abduction contracture. To bring the abducted leg into a vertical position the pelvis must be tilted downward on that side, thus causing an apparent lengthening of the leg. (Redrawn from Leo Mayer, J. Bone and Joint Surg.)

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Operations on the Pelvis —*Pelvic Obliquity (Pelvic and Trunk Disalignment in Poliomyelitis)* —Pelvic obliquity may occur in the antero posterior or lateral directions, causing lordosis or scoliosis respectively

Pelvic Obliquity in the Antero-posterior Direction —In the sagittal plane the psoas muscles by virtue of their insertion into the lesser trochanters, flex the lumbar spine and pelvis against the thigh if the latter is fixed conversely, they flex the thigh against the fixed lumbar spine The external oblique muscle also is a forward flexor of the body against the pelvis and so is the internal oblique, if the latter acts synchronously, whereas the unilateral action of either oblique produces lateral bending and rotation Paralysis of these muscles greatly disturbs the antero-lateral balance of the pelvis and trunk as they are superimposed on the hip joints

In cases of lateral contracture and lateral imbalance when the pelvis is tilted in the frontal plane, the quadratus lumborum and the oblique and transverse abdominal muscles acting asymmetrically produce a lateral deviation The principal disalignment occurs in the lumbosacral junction and lumbar spine Substitution of paralyzed muscles can be made by the insertion of fascial strips according to Lowman's method The strips are inserted laterally from the costal arch to the crest of the os ilia This must be preceded by correction of the deformity

FIXED PELVIC OBLIQUITY

In describing fixed pelvic obliquity Mayer mentioned four types of contracture (1) contracture of the abductor structures, (2) contracture of the adductor structures (3) combination of 1 and 2, (4) contracture involving the hip and back

Fascial Transplantation for Paralytic Pelvic Obliquity —For stabilizing the pelvis, Mayer modified Lowman's procedure by extending a fascial transplant from the 9th rib to the iliac crest, in the belief that recurrence of deformity can be prevented by attaching each end of the strip to the bone, rather than to bone and active muscle by the technic of Lowman

Mayer divides paralytic trunk deformities into three groups, depending upon the involvement of abdominal muscles and the quadratus lumborum

Group I unilateral paralysis of the abdominals and the quadratus lumborum results in fixed paralytic pelvic obliquity with scoliosis convex to the paralyzed side

Group II unilateral paralysis of the lateral abdominals with intact quadratus lumborum, results in scoliosis convex toward the paralyzed side but no fixed pelvic obliquity

Group III bilateral paralysis of recti abdominis and weakness of lateral abdominal and transverse muscles result in sagging abdomen increased lordosis, forward tilting of pelvis and horizontal sacrum

Following correction by push and pull devices and turnbuckle plasters supplemented if necessary by stripping operations to release contracted structures permanent correction can be secured not by fusion of the spine alone but by an iliocostal fascial graft which effectively supports the tilted pelvis and helps to restore normal muscle balance to the involved trunk muscles In some cases this should be supplemented by spine fusion

Ransohoff emphasized the importance of the earlier control of pelvic obliquities. When pelvic obliquity is developing he urges early fascial transplant.

Mayer makes a plea for the early recognition of trunk muscle imbalance so that scoliosis can be prevented. A transplant of fascia is the best means of strengthening the weak or paralyzed muscle.

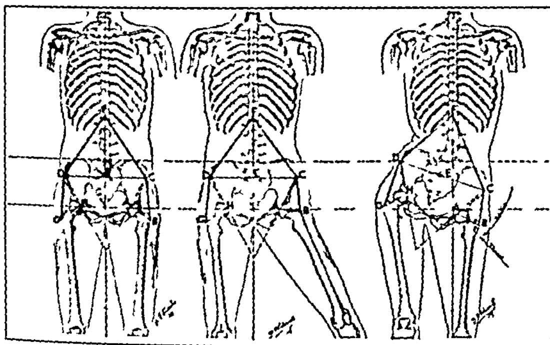


Fig. 266 Fig. 267 Fig. 268

Fig. 266.—A balanced skeleton. Notice the symmetry of the triangles above and below the iliac crests, the sides of which represent the lateral trunk and the hip abductor lever systems respectively.

Fig. 267.—A hip abduction contracture represented by the double line *BC*. The pelvis is the fixed point from which the shortened abductors abduct the thigh. The deformity is localized.

Fig. 268.—When the abducted extremity, as shown in Figure 267, swings into position for weight bearing, the femur becomes the long arm of a lever pulling through the contracted abductors *IC* and forcing the pelvis down on the same side. In addition, a lateral thrust is transmitted through the head and the neck of the femur to the acetabulum, displacing the pelvis to the opposite side. There has been complete disruption of all lever system and weight bearing thrusts concerned with locomotion. (Irwin, courtesy of Jour. Am. Med. Assn.)

The paralysis of groups of trunk muscles results in a definite deformity of the trunk. This deformity is a contracture. Mayer's study of poliomyelitic cases with paralysis of the trunk muscles has led to the tabulation of three groups of paralytic deformities.

In the first there is a unilateral paralysis of the external and internal oblique abdominal muscles and of the quadratus lumborum of the same side. This results in a lumbothoracic scoliosis convex toward the paralyzed side and in a downward tilt of the pelvis on the same side; the pelvis, in turn, becomes fixed in this position, the so-called fixed paralytic pelvic obliquity.

In the second group the internal and external oblique muscles of one side are involved, but the quadratus lumborum is not paralyzed. There de-

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Following correction by push and-pull devices and turnbuckle plasters, supplemented if necessary by stripping operations to release contracted structures, permanent correction can be secured not by fusion of the spine alone, but by an iliocostal fascial graft which effectively supports the tilted pelvis and helps to restore normal muscle balance to the involved trunk muscles In some cases this should be supplemented by spine fusion

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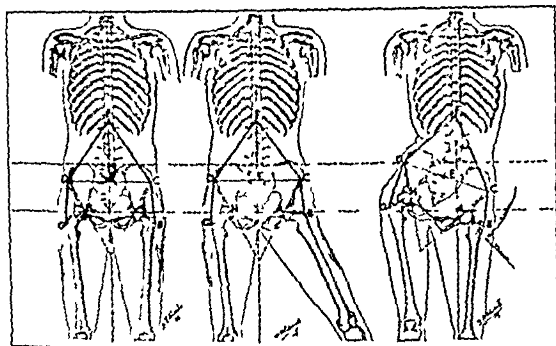


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In the second group the internal and external oblique muscles of one side are involved but the quadratus lumborum is not paralyzed There de-

velops a lumbothoracic scoliosis, convex toward the paralyzed side, as in the first group, but the intact quadratus prevents a downward tilt of the pelvis, and consequently, the fixed obliquity characteristic of the first group does not occur

In the third group, there is a bilateral paralysis of the recti abdominis with bilateral weakness of the external and internal oblique and transverse muscles As a result, the pelvis, when seen in sagittal section, tilts forward so that the plane of the pelvic inlet forms an angle of 60 degrees or more

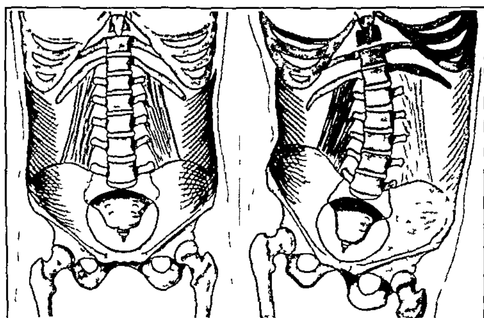


Fig 269 Fig 270

Fig 269 —Diagrammatic drawing illustrating the relation of the lateral abdominal muscles and of the quadratus lumborum to the pelvis

Fig 270 —This illustrates the effect of a unilateral paralysis of the lateral abdominals and the quadratus lumborum of the left side The unopposed strong muscles of the right side pull up the right side of the pelvis the left side tilts downward and a left convex lumbo thoracic curve develops If uncorrected the deformtiy becomes fixed (Mayer courtesy of Jour Bone and Joint Surg)

instead of the normal angle of 30 degrees, the abdominal wall sags markedly, the lumbar lordosis is much increased, and the sacrum assumes a more nearly horizontal position

There is considerable overlapping of the three groups The sacrospinalis and the other spinal muscles unquestionably play a role in paralytic trunk deformities Greenberg and Mayer have shown that there is a definite ratio of three to six between the strength of the flexors of the trunk, the lateral muscles and the extensors Any variation from this ratio may eventually lead to a permanent deformity

It is important to recognize weakness of the trunk muscles at an early period following the attack of infantile paralysis since early recognition makes complete correction possible, where as long delay leads to the development of deformities Tests have already been published, by Lowman and

by Mayer Of particular value are the lateral swinging tests and the blowing test for the lateral abdominals, and the pelvic-elevation test for the quadratus lumborum

Minor grades of trunk deformity may be corrected by non operative procedures These involve the well-established principle of stretching the tight or contracted muscles so as to allow the relaxed, weaker muscles an opportunity to regain their normal resting length This can be done by the push and pull apparatus which exerts traction on the high side of the pelvis and an upward push on the low side The well leg traction splint can be utilized for the same purpose In some patients where the deformity is somewhat greater, skeletal traction through a Kirschner wire is effective in pulling down the high side of the pelvis The scoliosis can frequently be corrected by a turnbuckle plaster used by itself or in conjunction with the Roger Anderson apparatus where fixed pelvic obliquity complicates the scoliosis

The sagging abdomen and the anterior tilting of the pelvis can be combatted by suspension in a hammock or by suitable tilting of a Gatch bed so as to relax the weakened anterior abdominal muscles

When fusion of the spine fails, the recurrence is due to unbalance of the trunk muscles Lowman's operation of a fascial transplant is advised

Irwin has emphasized the importance of the iliotibial band syndrome and the value of the Ober-Yount operation in young children There would be less pelvic trouble if the following measures were carried out more often in infants and very young children with minor rotatory defects Frejka Splint, Denis-Browne Splint and Leg 'twisters

Irwin finds subtrochanteric osteotomy to be a useful procedure in at least two conditions or deformities which may result from an attack of poliomyelitis, first uncorrectable fixed pelvic obliquity the obliquities which cannot be corrected by usual Soutter fasciotomies in combination with well leg traction apparatus and those for which Lowman's fascial transplant and Mayer's fascial stripping are ineffective second, certain cases of severe gluteus medius weakness when it occurs on one side

Technic of Irwin's Operation —One inch of the shaft of the femur in the subtrochanteric region is exposed A Steinmann pin is inserted engaging both medial and lateral cortices proximal to the site of the proposed osteotomy A L shaped portion of bone is removed from the femoral shaft including the lateral anterior and posterior cortices Three-eighths inch of the medial cortex is left intact The portion of bone removed is cut up in small shavings and replaced in the recess The incision is closed in layers A double spica cast is applied incorporating a Steinmann pin The osteotomy is not completed at the time of operation

Four weeks postoperatively with the patient under anesthesia a wedge shaped portion of plaster is removed just below the pin with the base to the lateral side The remaining medial cortex is fractured and the distal fragment abducted Since the first procedure sufficient callus has formed around the replaced bone shavings to prevent any displacement At no time is there a complete separation of fragments The osteotomy is completed by greenstick fracture, the new callus being used as a hinge The proximal fragment is fixed by a Steinmann pin incorporated in the cast

Six weeks postoperatively the Steinmann pin is removed and two weeks later sufficient callus has formed to allow removal of the cast The entire procedure is completed within a period of eight weeks with practically no discomfort to the patient and a minimum amount of surgery and internal fixation

Knutsson described the lesion as a more or less widespread and intensive sclerosis within the ilium in the vicinity of the sacroiliac joint The joint space is intact Sclerosis was found within the juxta articular part of the sacrum The condition occurs predominantly in women

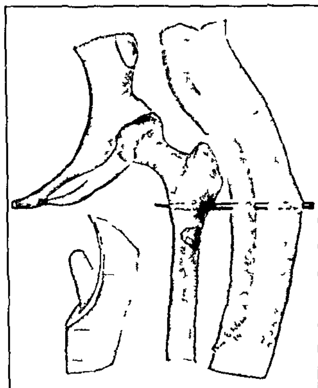


FIG 271 —First stage of the osteotomy consists in removing a U shaped portion of bone just below the greater trochanter The bone is cut up into chips and replaced in the recess A Steinmann pin is inserted proximal to the osteotomy site engaging both cortices (Irwin courtesy of Jour Am Med Assn)

Scanty attention has been shown to osteitis pubis by orthopedic surgeons over the past twenty-five years Since 1934 only four papers have been written and but 5 cases presented The urological literature however abounds with case descriptions and theories concerning the etiology and pathology of osteitis pubis Beach hails the entity as "an orthopedic disease sponsored by urologic surgery" Kirz estimates that osteitis pubis develops in 3 per cent of patients undergoing suprapubic operation

Adams and Chandler advise that osteitis pubis of traumatic origin should in general be treated conservatively Complete bed rest may be necessary in the acute phase and a plaster of Paris spica may be required to limit still further hip and pelvic motion in such instances Later with improvement, a snugly drawn sacroiliac belt might be useful to decrease

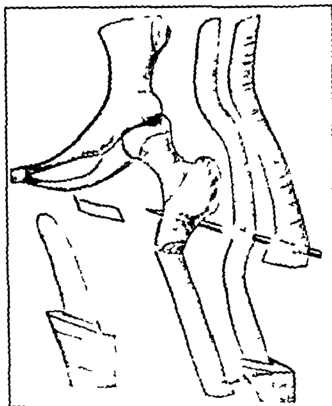


Fig. 272.—The osteotomy is completed four weeks later by *manual osteoclasis*. The newly formed callus around the bone shavings acts as a hinge. The proximal fragment is held in position by the Steinmann pin incorporated in the chest. At no time is there complete fracture. (Irwin, courtesy of Jour. Am. Med. Assn.)

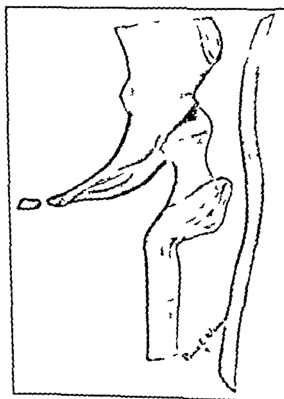


Fig. 273.—The Steinmann pin is removed at the end of six weeks. The osteotomy site is usually solidly fused at the end of eight or ten weeks. (Irwin, courtesy of Jour. Am. Med. Assn.)

Six weeks postoperatively the Steinmann pin is removed and two weeks later sufficient callus has formed to allow removal of the cast The entire procedure is completed within a period of eight weeks with practically no discomfort to the patient and a minimum amount of surgery and internal fixation

Knutsson described the lesion as a more or less widespread and intensive sclerosis within the ilium in the vicinity of the sacroiliac joint The joint space is intact Sclerosis was found within the juxta-articular part of the sacrum The condition occurs predominantly in women

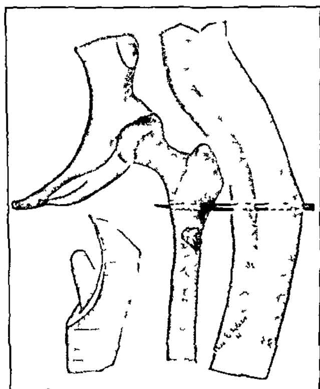


FIG 271 —First stage of the osteotomy consists in removing a U shaped portion of bone just below the greater trochanter The bone is cut up into chips and replaced in the recess A Steinmann pin is inserted proximal to the osteotomy site engaging both cortices (Irwin courtesy of Jour Am Med Assn)

Scanty attention has been shown to osteitis pubis by orthopedic surgeons over the past twenty-five years Since 1934 only four papers have been written and but 5 cases presented The urological literature, however, abounds with case descriptions and theories concerning the etiology and pathology of osteitis pubis Beach hails the entity as "an orthopedic disease sponsored by urologic surgery" Kirz estimates that osteitis pubis develops in 3 per cent of patients undergoing suprapubic operation

Adams and Chandler advise that osteitis pubis of traumatic origin should in general be treated conservatively Complete bed rest may be necessary in the acute phase and a plaster of Paris spica may be required to limit still further hip and pelvic motion in such instances Later, with improvement, a snugly drawn sacroiliac belt might be useful to decrease

Osteitis pubis is considered by the majority of authors to be an inflammatory disease of bacterial origin which occurs most commonly following retropubic surgery in males

Osteitis Pubis.—Osteitis pubis is most commonly seen following prostatectomy but has also been reported in association with difficult labor, trauma to the lower abdomen hermorrhaphy, pyelonephritis prostatic abscess, and genitourinary instrumentation From eight to sixteen days after the operation or trauma the patient suddenly complains of severe pain in the pubic area, with possible radiation to the inner thighs or groin or slightly upward on the abdomen Wood all found a point of severe tenderness over the symphysis Slight generalized enlargement or widening may be palpable There is marked spasm of the adductor thigh muscles attached to the pubis, and any attempt to abduct or rotate the legs causes extreme accentuation of the pain If the patient agrees to stand or walk at all it is with great reluctance and the movements are quite guarded, slow, and painfull Coughing, sometimes micturition and defecation, or any movement or pressure in the pelvis direct or indirect (as in standing or sitting), increases the pain in the pubic arch The roentgenologic picture is that of acute bone atrophy, but usually this is evident only after the third week It consists of an early fuzziness and fraying of the periosteum then rarefaction with decalcification and separation of the symphysis (the process being at its maximum during the fourth to sixth week) Subsequently there may be simultaneous healing of rarefied bone with sclerosis while osteolysis is progressing elsewhere The disease is self-limited lasting from two to eight months In view of the prognosis, treatment is directed chiefly toward relieving the pain and spasm Two cases are presented In the second, cortisone and streptomycin in combination seemed to lessen the pain and shorten the course

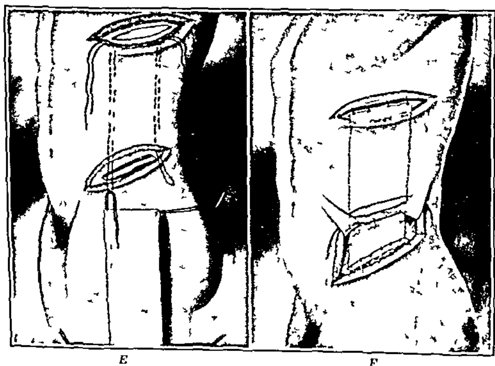


FIG 274 —*(Illustration continued from opposite page.)*

symphyseal movement during weight bearing. Ambulation should be resumed as soon as it can be tolerated, but strenuous activities should be minimized until roentgenographic and clinical signs indicate healing. The administration of antibiotics is of value during the acute phase, if signs of gross infection become manifest. When abscess formation occurs, which is rare, incision and drainage should be done.

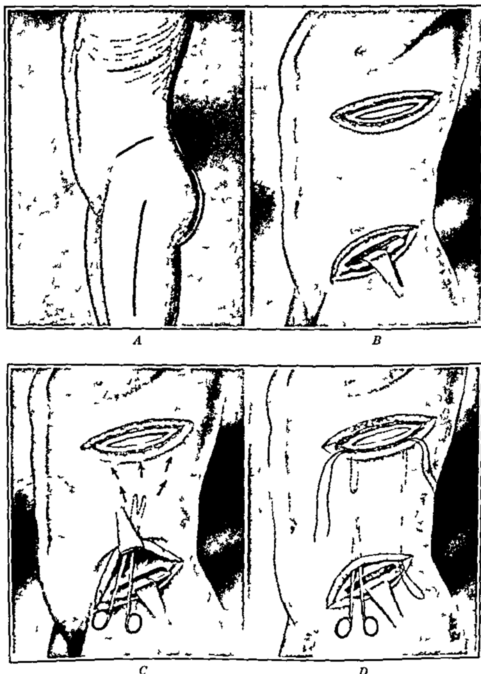


FIG 274 — *A* The three incisions for the removal and insertion of the fascial graft. *B* Exposure of the ninth rib and the iliac crest. *C* Construction of the tunnel connecting the iliac crest and the ninth rib. The tunnel must be at least three inches wide. *D* Passage of the guide sutures through the tunnel. *E* The fascial sheet is about to be drawn through the tunnel by means of the guide suture. *F* The fascial sheet has been fastened under tension to the iliac crest and the ninth rib. The lateral sutures taken in the abdominal musculature hold the fascia flat and prevent it from rolling. (From Mayer, courtesy of Jour Bone Jt Surgery)

of the pelvis and finally serious sequelæ Chondromas of the pelvis are not always benign and after a slow growth may suddenly increase in volume removal being followed by recurrence

Extirpation of tumors of the iliac wing *en masse* would be ideal, unfortunately when they have spread to the hip the operation becomes extensive In every case, resection is less grave than curettage of the lesions, as cavity surfaces are easily infected When a complete operation cannot be performed, it is best to refrain from operating, the patient may lead an active life for a long time despite the lesion, and the operative mortality is high

Sloat and Peterson reported the case of a patient with Ewing tumor of the sacrum in whom intensive roentgen therapy after biopsy, produced a five-year survival

A sacrococcygeal tumor may be an ependymoma, teratoma, chordoma, neuro-epithelioma or giant cell tumor Giant cell tumor and ependymoma usually occur within the body of the sacrum Teratoma and chordoma are common in this region

Chesky found that chordomas develop from aberrant notochordal tissue chiefly in the sacrococcygeal regions Sacrococcygeal tumors occur mostly during the fifth decade of life They are slow-growing malignant tumors, producing death by extension rather than by metastasis They are resistant to roentgen-rays Although they nearly always recur after removal life may be prolonged by surgical treatment

Lymphangioma of soft tissue is not an uncommon condition So far as can be determined, however, Bickel and Broders could not find a recorded case of primary lymphangioma of bone

Histologically, the periosteum of normal bone contains a rich plexus of lymphatic capillaries It is possible that this tumor arose in the periosteum and gradually caused dissolution of the ilium ischium and portions of the vertebræ, by invasion of the blood and lymph spaces contained therein Not much is known about the lymphatic vessels of the bone marrow and cancellous bone but such porous structures rich in body fluids, must certainly contain lymphatic vessels It is known that lymphatic vessels do accompany the blood vessels in the Haversian canals Hence it is conceivable that this tumor could arise primarily within the bone

HINDQUARTER AMPUTATION

Gordon-Taylor described interinnomino-abdominal or hindquarter amputation as one of the most colossal mutilations practised on the human frame' In 1934 in collaboration with Wiles he reviewed all cases reported in the literature and showed that the mortality rate had been 60 per cent In 1939 he reported 11 personal cases Since that time the operation has been practiced with increasing success Reports were made in 1942 by Leighton and in 1943 by King and Steelquist Twelve hindquarter amputations were reported by Beck and Bickel

The operation is one of great magnitude and should be undertaken only after careful deliberation In recording 5 cases Brittain shows that optimism may be justified It has even been possible to fit these patients with artificial limbs and teach them to walk without crutches

OSTEITIS CONDENSANS ILII

This lesion owes its roentgenological definition to Barsony and Polgar Hare and Haggart and others

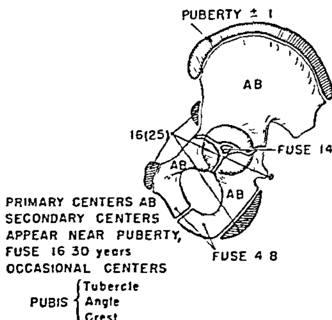


Fig 275 —Ossification center of the innominate bone

TUMORS OF THE PELVIC BONES

According to Tavernier and Pouzet malignant tumors of the pelvis have sharply defined characteristics Their roentgenograms are distinct and their evolution is rapid The evolution of benign tumors of the pelvis is slow and they have a long latent period The authors reported a fibroma a myeloplaxoma a hydatid cyst and two chondromas In all the benign tumors excepting the chondroma the iliac bone was enlarged *en masse* but one may distinguish two types a spongy bone with a special trabeculation but without destruction is a fibroma an undifferentiated tumor a spongy bone with cavities and zones of destruction may be a myeloplaxoma or a hydatid cyst

The osteosarcoma evolves rapidly and soon rarefies the ilium Benign tumors, on the contrary are insidious produce no recognizable symptoms and increase in volume slowly Roentgenograms of the chondroma reveal a mass adjacent to the bone with a cauliflower aspect and with disseminated ossifications in the tumor The series of benign tumors enlarge the ilium in a regular manner with variable trabeculation Persistence of the cortex, even though deformed is a sign of benignity Finally there is the large spongy ilium with areas of destroyed bone In the latter condition the diagnosis is between osteosarcoma hydatid cyst and a myeloplaxoma is difficult

The prognosis is unusual because extirpation of tumors of the pelvis is difficult. Their development causes progressive alterations in the solidity

The person interested in this subject will find a complete description with illustrations in Lewin's book The Knee (Lea & Febiger, 1952)

The Problem may be resolved into the following categories (1) Recognition of inequality of length (2) Accurate determination of discrepancy (3) Accurate estimation of future growth (4) Determination of procedure to be followed (5) Timing of procedure (6) Precision surgery (7) Aftercare

The Solution In equalizing leg length differences, five procedures may be considered First The long leg can be shortened Second the short leg can be lengthed Third in children the growth of the long leg can be retarded Fourth Acceleration of growth of the short leg may be tried but does not offer much practical hope Fifth Mechanical adjustments of shoes

Phemister in 1933, proposed an operation for epiphyseal arrest which laid the foundation for much of the work that followed Haas successfully arrested growth without destroying the epiphysis by the use of removable rustless steel wire looped about the distal femoral epiphysis

Blount's latest contribution has shone a brighter spotlight on the entire situation This method is a definite step forward in preserving the life of the epiphysis and in temporarily arresting growth by means of metal staples

Growth arrest and control operations assure the affected child if seen early enough, and if the deformity is not too severe, equality of leg length at growth maturity

Leg shortening and lengthening operations are major procedures

The operation of arrest or control of growth of the epiphyses is a procedure to be employed in growing children for the correction of discrepancies in leg length, due to a variety of conditions

In poliomyelitis cases, Steindler found that the degree of shortening *varied directly* with the severity of the paralysis and inversely with the age at onset Decrease in or loss of leg length occurs over a period of years until cessation of growth The greatest loss occurs during the period of most rapid growth

Two Important Factors in the Problem are 1 Predicted Growth 2 Anticipated Growth

Tables of Estimation of Growth have been proposed by Digby, Hatcher, Green Stinchfield and others

ORTHORADIOGRAPHIC MEASUREMENT OF SHORTENING OF THE LOWER EXTREMITY

Farill described a radiographic method for the evaluation of inequalities in length between the lower extremities This *technic permits accurate* calculation of segmental as well as total shortening It can be carried out with ordinary x-ray equipment The method is based on the following premise If from two distances of equal or different length the same length is subtracted the equality or difference between them is not altered This can be expressed mathematically A radiographic table is employed in which the Potter-Bucky *diaphragm can travel from one end to the other* with the cassette carrier

CHAPTER 39

EQUALIZATION OF LENGTH OF LOWER EXTREMITIES

THE subject of inequality of length of legs has been of great interest for many years Its relation to back disorders may be very close

Rizzoli, Fassett, Taylor, Putti Magnuson, Abbott, Phemister, Brookes, White and Stubbins, Steindler, Green Haas, Blount and many others have made significant contributions When Phemister announced his growth arrest concept in 1933 the matter became of greater interest

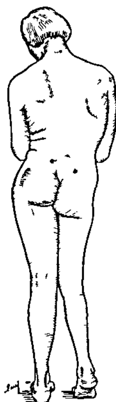


Fig 276

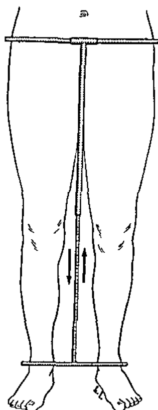


Fig 277

Fig 276 —This seventeen year old girl had poliomyelitis when she was two years old Because of the flail right knee with involvement of all groups of muscles tendon transplantation was not possible and an arthrodesis was performed When she stood on both feet there was a total right scoliosis the right gluteal crease was 2 inches lower than the left the dimple at the posterior superior iliac spine was lower on the right the right iliac crest and anterior superior spine were low there were three folds in the left iliocostal angle and none in the right When wood splints were placed under the right foot until it was raised 2 inches the pelvis was level and the scoliosis corrected (Drawn from photo) (Note A leg shortening operation was advised)

Fig 277 —Delbet s apparatus for measuring length of lower extremities

The person interested in this subject will find a complete description with illustrations in Lewin's book The Knee (Lea & Febiger 1952)

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The clinically selected levels are marked with a skin pencil on the hips and over the joint spaces of the knees and ankles

Leveling or Balancing the Pelvis in Cases of Inequality of Lengths of the Legs —It is necessary to emphasize the importance of balancing the pelvis in cases of infantile paralysis congenital shortening of a leg, fractures involving a leg or disease of the bones or joints of the pelvis and lower extremity and many other situations This can be done only after a careful examination of the bare dorsal surface of the body, while the patient stands

Rhomboid of Michaelis —The rhomboid of Michaelis is a diamond shaped depression formed by the gluteal muscles and the groove at the end of the spine If this rhomboid is outlined on the patient while he is standing the vertical axis should be parallel with the long axis of the body (Fig 278)



Fig 278 —Farill's method for determining [illegible] lities of leg length by x ray

The procedures available after maturity are direct lengthening or shortening of one of the long bones. Ordinarily in shortening the femur is the bone that is chosen, and in lengthening the tibia and fibula are selected.

Leg shortening has become a more popular procedure. The femur can be shortened by one of many technics. Skeletal fixation is essential since the removal of bone reduces the compression factor in fixation and in healing. The musculature and the tissues adapt themselves to the removal of considerable bone.

Lengthening has in its favor the fact that the operation is performed on the shorter leg, which ordinarily is the abnormal one.

Approximate Proportional Growth at the Epiphyses of the Lower Extremity*

Upper femoral epiphysis	15%
Lower femoral epiphysis	35%
Upper tibial epiphysis	30%
Lower tibial epiphysis	20%

* Wilson and Thompson

In 1947, Green published a chart based upon the annual increments of growth of the bones of the lower extremity between consecutive ages as measured on orthoroentgenograms of the children.

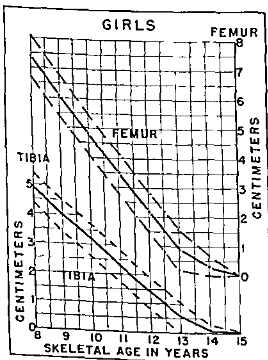


Fig 279

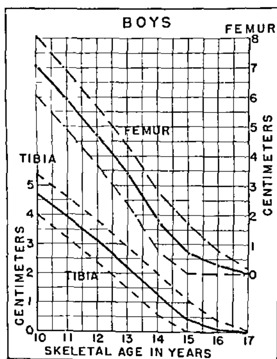


Fig 280

Figs 279 and 280 —From these tables prepared by Green and Anderson the amount of growth to be eliminated after epiphyseal arrest can be estimated. Central line represents average correction, secondary lines the useful range. Extremes are not indicated. (Green and Anderson, courtesy of J Bone & Joint Surg.)

The clinically selected levels are marked with a skin pencil on the hips and over the joint spaces of the knees and ankles

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Fig 278 —Farill method for determining inequality of leg length by x ray

When the patient has reached the age of eight years the question arises of slowing down the longer side by epiphyseal arrest or control. At the end of the growth period, i.e., practically after the age of thirteen or fourteen years, various equalization methods are to be considered, especially when the inequality becomes burdensome, i.e., 9.5 cm. or more, which is nearly 4 inches.

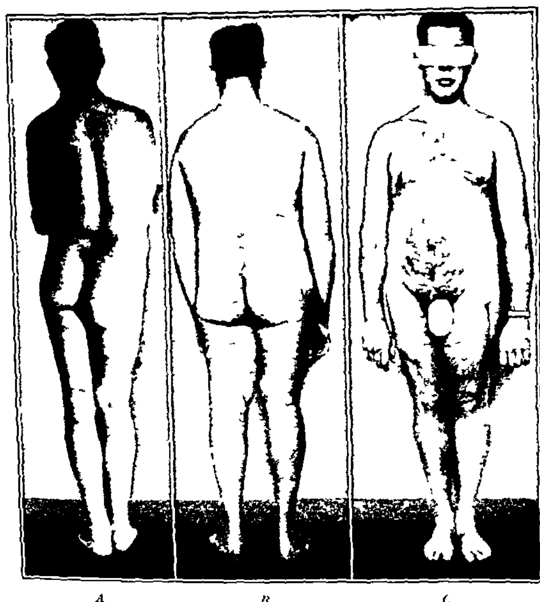


FIG. 283.—*A*, Four inches shortening of right leg due to old healed osteomyelitis of femur. Note scoliosis and pelvic imbalance. *B* and *C*, After equalization of leg length by shortening left femur 4 inches. Note disappearance of scoliosis and perfect leveling of gluteal creases. (Operation by Lewin and Sideman.)

ARREST OF EPIPHYSEAL GROWTH

Arrest of epiphyseal growth involves a minimum of risk to the extremity and to life. Phemister's surgical arrest of the longitudinal growth of bones, consists of artificial fusion of the epiphyses at the lower end of the femur

In a *revised chart,* one can observe the child's skeletal age and read the average predicted effect of an arrest of the particular epiphysis along with a range of deviation The chart must be considered as representing a guide rather than an accurate prediction of the effect of an arrest Many factors enter into the absolute amount that is obtained by the procedure

Leg Shortening Operations —Leg shortening operations should not be performed until after growth has been completed There is always the possibility of a continuing disturbed rate of unequal growth which may lead to later discrepancy in the length of the limbs Moreover, the resulting hyperemia may lead to an increased rate of growth on the shortened side Either of these factors might invalidate the ultimate equalization

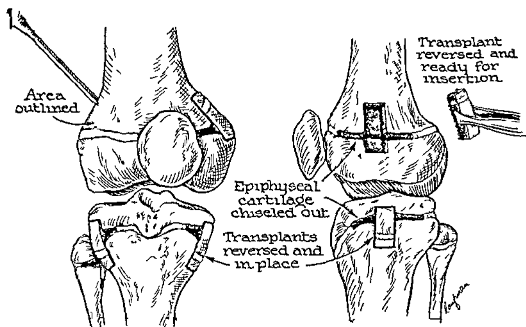


Fig 281 —Epiphyseal arrest (Redrawn Phemister courtesy of Jour Bone & Joint Surg)

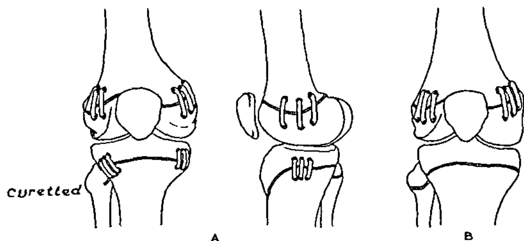


Fig 282 —Diagrammatic representation of the control of linear growth Three staples are a unit *A* The femur and tibia are too long *B* The femur alone is too long (Courtesy of Blount)

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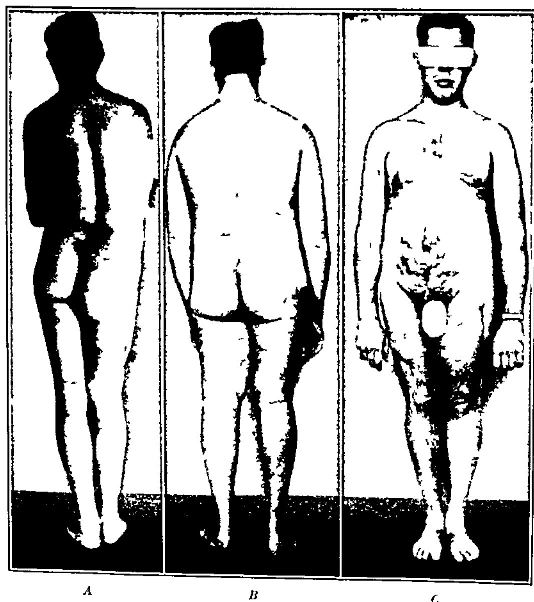


Fig. 283. — *A*, Four inches shortening of right leg due to old healed osteomyelitis of femur. Note scoliosis and pelvic imbalance. *B* and *C*, After equalization of leg length by shortening left femur 4 inches. Note disappearance of scoliosis and perfect leveling of gluteal creases. (Operation by Lewin and Sideman.)

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and lower or upper end of the tibia and fibula of the normal member It is designed to retard growth in the normal extremity while the short member is allowed to grow so that the length of the two may be equal when maturity is reached This procedure is applicable only to children who have a growth expectancy of several years Several modifications of Phemister's original technic have been proposed

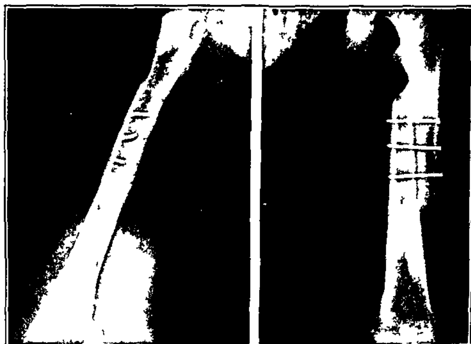


Fig 284 —Shortening of femur 4 inches Transverse osteotomy Roughening of periosteum Flattening of opposing femur surfaces Three vitallium screws engaging 4 cortices (Operation by Lewin and Sideman)

EPIPHYSEAL ARREST BY STAPLING

The staples which Blount uses are similar to those employed by Burns Delitala and Dujarrier for the maintenance of position and apposition following stabilizations arthrodesis and osteotomies This procedure is designed to arrest growth by mechanical means without destroying the epiphyseal plate When the desired deformity or length inequality has been sufficiently corrected the staples may be removed and growth from the epiphyseal plate permitted to continue The procedure has a wide range of usefulness

The following discussion of epiphyseal arrest by stapling was prepared by Blount whose experience with the method has been wider than that of others and is quoted from the book by Campbell-Speed

Staples are effective in the arrest or retardation of the growth of an epiphysis Staples made of 3/22 inch rods of type 302 chrome nickel stainless steel with legs $\frac{3}{4}$ inch long and cross members $\frac{5}{8}$ inch long are preferred At least two must be used on either side of an epiphysis for complete arrest and in older children it is better to use three because the growth pressure is tremendous Cessation of growth at the epiphysis following stapling is

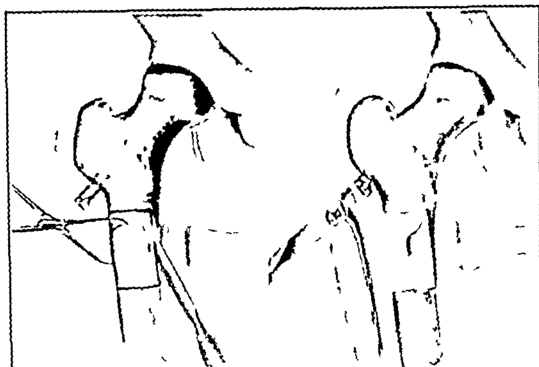


Fig. 285.—Plate is about to be attached to nail. Later, just before closure of incision, the connecting screw should be tightened forcibly with a large screw driver. Note flange of bone which has been retained. (Thornton, courtesy of Jour. Bone & Joint Surg.)

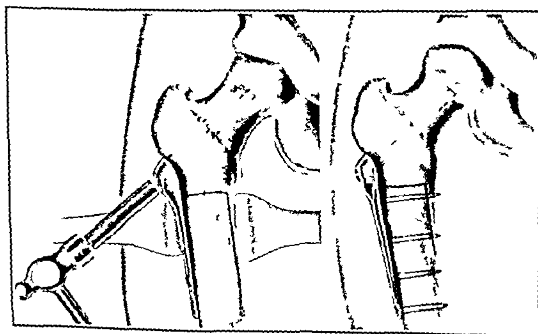


Fig. 286   Fig. 287

Fig. 286.—Fragments have been aligned. The nail has been driven in completely.

Fig. 287.—The plate has been fastened to the femoral shaft so that the screws engage both cortices. (Thornton, courtesy of Jour. Bone & Joint Surg.)

complete and immediate but not final Staples have been used on one side of an epiphysis and a growth arrest operation on the other with equal efficiency

Blount finds that staples may be used and removed when indicated, with full resumption of growth If the staples are not left in too long, this may occur, but Green questions whether sufficient evidence has now accumulated to reveal whether such resumption of growth is dependable If it can be established that growth will resume consistently at its regular rate when staples are removed, stapling will become the procedure of preference

A clamp serves to hold the overlapping bones in proper position while the pins are being placed As the compressed bulk of shortened muscles tends to elongate the thigh, the two pins (bicycle spokes) are placed parallel and obliquely about an inch apart, so that the expansive tendency will force the parallel fragments together

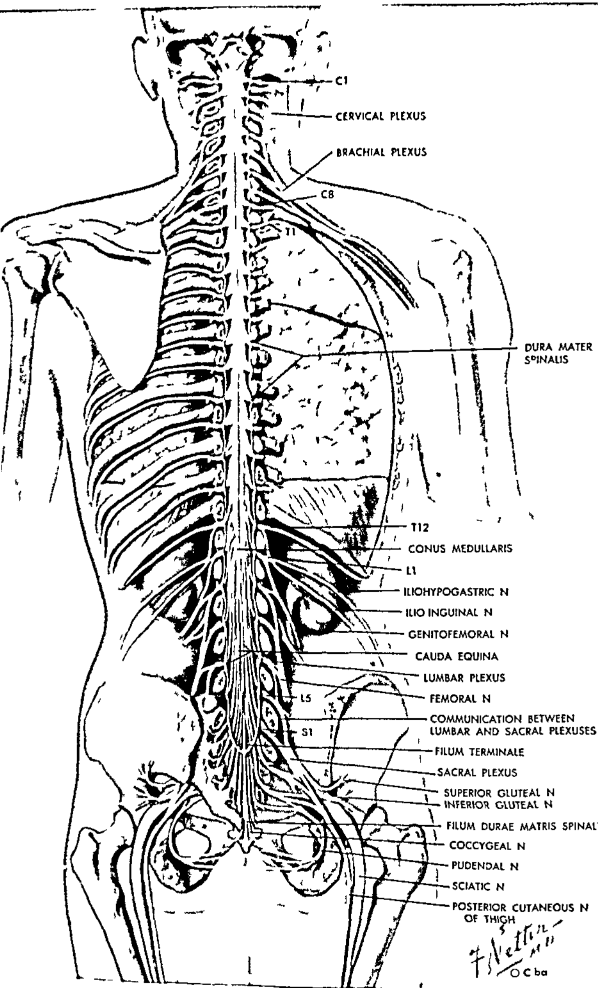
The pins are allowed to project a quarter of an inch beyond the bone on the further side and to come out through the wound In arranging the overlapping bones, care must be taken that they lie in the same plane as the wound so that the parallel pins can project out of the wound without *straining the suture line*

A plaster hip spica is applied from the toes to above the costal border with the hip slightly flexed and abducted, the knee somewhat flexed and the foot at a right angle The pins are incorporated in the cast and, after they are cut off so as to allow about an inch to project, they are bent at right angles flush with the surface of the cast A few turns of plaster covers them The point is marked so that at the end of four weeks the bent-down end can be easily found and the pins pulled out The cast is removed at the end of another four weeks and if the *x*-ray shows good callus physical therapy is started and weight bearing, when advisable

Thornton's Technic of Subtrochanteric Limb Shortening —Blount's method has been outstanding in trochanteric shortening and White's in shortening the shaft of the femur

The Thornton technic is essentially that used in the treatment of trochanteric fractures

PLATE III



Spinal Cord in Situ (From *Ciba Collection of Medical Illustrations* Vol I—The Nervous System)

Part II

Neurological Lesions Affecting the Back

CHAPTER 40

BASIC NEUROLOGICAL DISORDERS

It is impossible to understand any of the neurological disorders affecting the back without a comprehensive knowledge of the anatomy of the central and peripheral nervous systems

Anatomy—The fully developed spinal cord begins at the medulla oblongata and ends as the conus medullaris at the lower level of the 1st lumbar vertebra The dural sac continues down to the lower border of the 2d sacral vertebra The sac contains cerebrospinal fluid and the cauda equina which is made up of the lumbar and sacral nerve roots Between the dural sac and the periosteum of the bone there is an epidural space filled with semifluid fat

The spinal cord has two enlargements one in the cervical the other in the lumbar region Any mechanical changes in these two areas can cause secondary pressure changes on the component nerves of the cervical brachial and lumbosacral plexuses

Barr refreshes your memory when he states that the fourth and fifth lumbar nerve roots enter the spinal canal through foramina which are narrowly circumscribed by the intervertebral disk and adjacent vertebral bodies the articular facet capsule and the adjacent pedicles of the vertebræ The first sacral root crosses the lateral aspect of the lumbosacral interspace obliquely as it courses toward its sacral foramen lying between the fifth lumbar disk anteriorly and the facet posteriorly

Anatomical knowledge of the cutaneous distribution of the spinal roots is essential to the understanding of any syndrome that is manifested by radiculitis The spinal nerves are joined to the spinal cord by their dorsal and ventral roots which are frayed-out bundles of axons called the fila radicularia The dorsal root contains the spinal ganglion which is invested by dura mater Although the roots pierce the dura separately they are enclosed in a single tubular sheath of dura which includes the spinal ganglion and posterior root and thus ensheathed a spinal nerve occupies an intervertebral foramen

The spinal cord comes to an end opposite the intervertebral disk below the 1st lumbar vertebra Lumbar and sacral nerve roots which go to make up the sciatic nerve arise opposite the 12th thoracic and 1st lumbar vertebra The lumbar radicular vessesls are important sources of blood supply for the spinal cord

38

The examination includes a study of the deep reflexes, biceps, patellar, Achilles, Babinski, Oppenheim, Gordon, Chaddock, and superficial reflexes, corneal, pharyngeal, abdominal and cremasteric. A reflex is dependent on an intact reflex arc. Tests for motor function include observations of muscle power and gait and tests for atrophies and stability. Tests for sensory function include determination of reactions to heat and cold, to sharpness and dullness, and to touch. Touch tests may vary from stroking with a pin

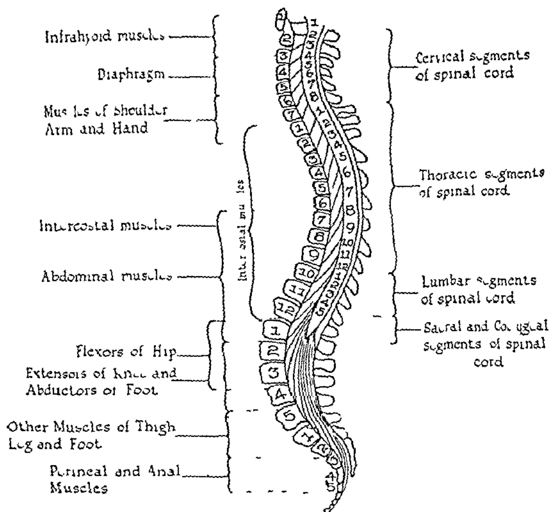


FIG 289 — Diagram showing the relationship of the various segments of the spinal cord to the vertebral bodies. The segments of the cord concerned with the innervation of certain related muscle groups are also indicated. (Davis and Haven)

or a wisp of cotton. Reactions to heat and cold are determined by alternately touching the skin with two test tubes, one of which is half full of warm water, the other half full of cold water. A wisp of cotton moistened with ether is a good object for testing the response to cold. Ethyl chloride spray is better.

Stereognosis means the ability to correlate and interpret various sensory impressions. This power enables a person to put his hand in his pocket and recognize various coins, keys or a watch. Electric tests include faradic, galvanic, chronaxia and the reaction of degeneration.

Head's definition of referred pain follows "Pain is felt in a part of higher sensibility rather than in a part of lower sensibility to which a painful stimulus is actually applied." The chief point of differentiation between "localized" and "referred" pain is the response to local pressure. In "localized" pain, local pressure intensifies, in "referred" pain pressure relieves, the discomfort.

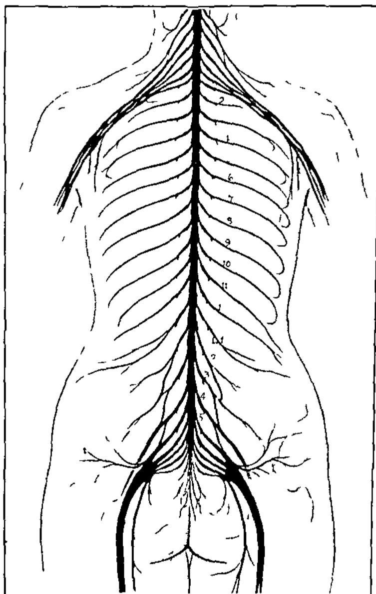


FIG 288.—Posterior view of spinal nerves. (Courtesy of S. H. Camp and Company.)

Originally the spinal cord was the full length of the spinal column. During the ascent of the cord which occurs as the spine lengthens any adhesions that might have formed would exert traction on the cord.

A neurological examination includes a routine clinical study by a competent neurologist. Information elicited by a detailed examination of reflexes, muscular strength, muscular tonus, sensory acuity, gait, coordination and balance, differentiate degenerative disease from compression lesions of the spinal cord.

Neurological Tests and Signs —The most important neurological tests and signs are the knee jerks, the Achilles reflexes and the Kernig, Lasegue, Fabere-Patrick, Brudzinski Babinski, Oppenheim and Gordon tests

Knee Jerks and Achilles Jerks —There is some discussion as to the exact significance of variations in the knee jerk and the Achilles jerk

The most important point to note is whether there is a difference between the two sides or a difference noted at various examinations The technic of elicitation demands that the position of the patient be relaxed, whether he is lying, while the examiner holds his knee at a 15 or 20 degree angle, or is sitting with his legs dangling over the table The hammer should be heavy, well balanced and not cause pain The point of contact should be a small area—and in the case of the knee, just over the patellar tendon

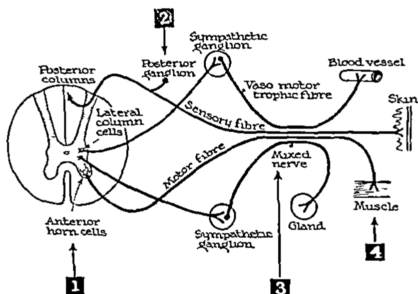


Fig 292 —Diagram of reflex arc (Gordon and Forrester Brown s Paralysis in Children courtesy of Oxford Med Publications)

and just above the tibial tubercle The type of stroke should be a quick forceful tap Normal response and variations are judged by experience Jandressak s maneuver is to have the patient lock his fingers, pull and look up at the ceiling in order to distract his attention

Brudzinski's neck sign is positive when passive forward flexion of the neck causes flexion of the thigh on the abdomen It is characteristic of meningeal irritation

The Babinski sign is positive when extension of the great toe and flexion of the other toes follows upward and inward stroking on the lateral border of the sole The sign indicates an organic lesion involving the upper motor neuron usually in the pyramidal tract

Oppenheim s test consists in drawing the handle of a percussion hammer over the inner surface of the leg from the upper margin of the tibia downward, whereupon one sees in normal persons either no movement at all in the foot and toes or a plantar flexion of the toes If the irritation is made strong enough distinct plantar flexion of the toes occurs It may be necessary to divert the attention of the patient to obviate voluntary movements In persons with pyramidal tract lesions, the manipulation causes dorsal extension of the big toe

Muscular branches
Ant ramus
Post ramus
Spinal nerve trunk
Post cutaneous branch
Communicating ramus
Spinal cord
Sympathetic ganglion
Lat div of ant ramus
Ant
Post root
Spinal gang
Ant root
Spinal cord
Nucleus pulposus
Annulus fibrosus
Ant cutaneous branch
Int vertebral venous plexus
Spinous process
Lig flavum
Basivertebral vein
Interspinal lig
Spinal cord
Posterior long lig
Disc

Fig 290 —Detail of a spinal nerve (Courtesy of S H Camp and Company)

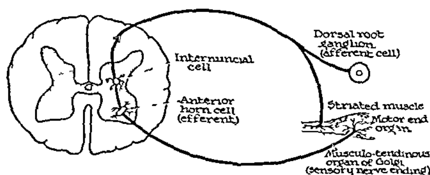


Fig 291 —Diagram of simple reflex arc (Redrawn *from* Gordon and Forrester Brown's Paralysis in Children courtesy of Oxford Med Publications)

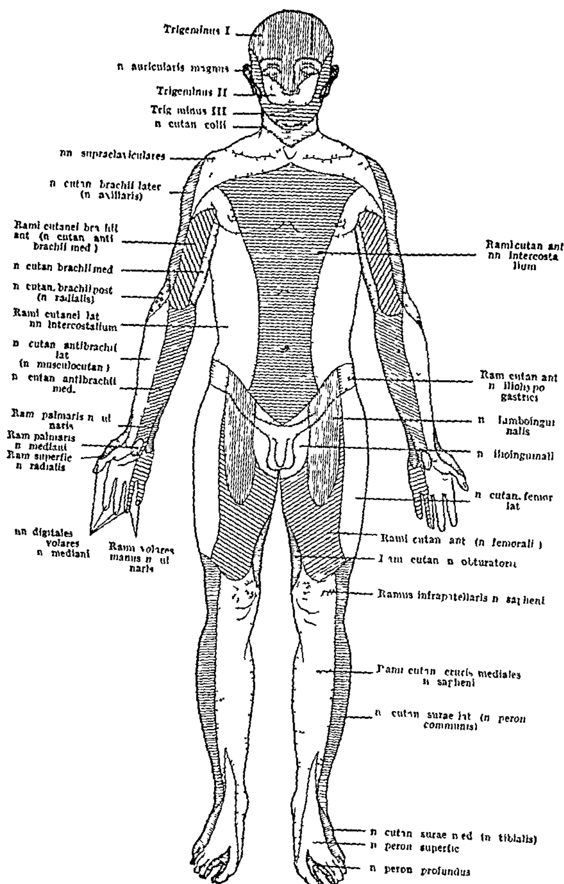


FIG 294 —Diagram of the superficial skin innervation on the ventral surface of the body (After Flatau in Grinker's Neurology courtesy of Charles C Thomas)

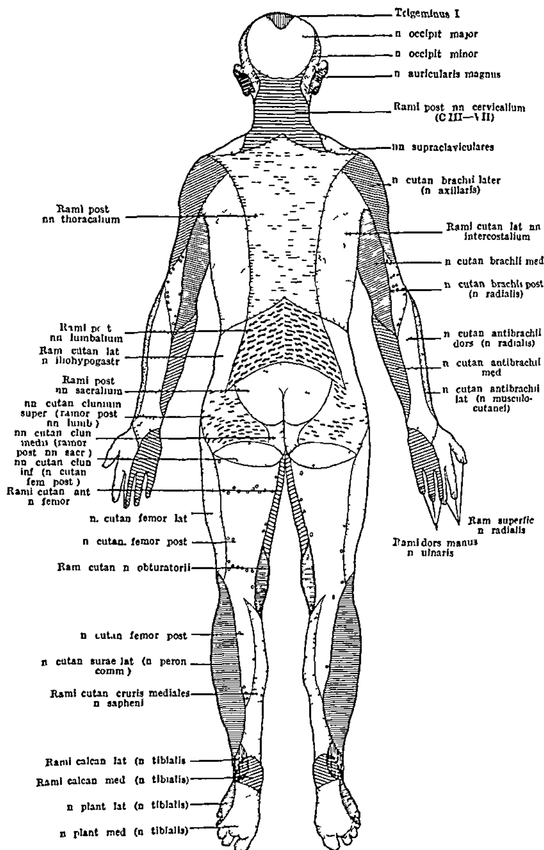


FIG 293 —Diagram of the superficial skin innervation on the dorsal surface of the body (After Flatau in Grinker s Neurology courtesy of Charles C Thomas)

Manometric Determination of Spinal Fluid Pressure — Pressure readings may indicate complete or incomplete subarachnoid block, or the presence of a free, unobstructed subarachnoid space. Normal pressure varies between 100 and 200 mm of water.

Queckenstedt's test indicates the presence or absence of interference with the circulation of fluid within the subarachnoid space. The normal level is first determined and the respiratory and circulatory oscillations observed, then the patient is told to "bear down." This, as well as deep breathing, coughing or blowing the nose, produces venous stasis within the thorax, prevents the blood in the thoracic vertebral space from emptying into the thoracic veins and causes a rise in the intrathecal pressure with a corresponding rise in the pressure of the cerebrospinal fluid to a point

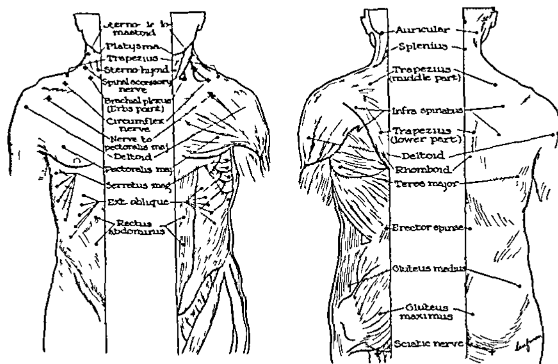


Fig. 298.—Motor points of the back. (After Pariset, from Lewin's Infantile Paralysis, courtesy of W. B. Saunders Company.)

at least double the initial pressure. After the level has returned to normal, the deep veins of the neck are firmly compressed by the fingers which are applied against the sides of the neck directly below the angles of the jaw. This produces a marked stasis of blood within the cranial cavity, extrusion of cerebrospinal fluid from within the cranium and if the subarachnoid space is free, a rapid rise in the level in the manometer until the fluid can be forced out of the top of the instrument. On release of the compression the fall of the level of the fluid is rapid and complete. If the circulation of the spinal fluid is completely impeded, the rise does not occur when the neck is compressed. When obstruction is partial, fluid may be forced past the obstructing mass with a delayed or imperfect rise and a slow fall, without a return to the normal level. If spinal fluid is now removed, the pressure may fall to zero and no fluid will subsequently appear in the

The Gordon test produces extension of the big toe when the calf muscle is compressed

The Chaddock test is positive when the big toe goes into extension after stroking around the external malleolus

Electric Reactions—Every normal muscle reacts to both faradic and galvanic currents The former elicits tonic contraction, persisting as long as the current flows through the nerve and muscle while the latter produces a contraction with the cathode only, when the current is turned on The reaction of degeneration has been described as either a partial or complete impairment of the ability of a nerve or muscle to react normally to electrical excitation It indicates a lesion of the lower motor neuron

Lumbar Puncture—Cerebrospinal Fluid Studies—Spinal fluid analyses include physical chemical, histological, biological and bacteriological

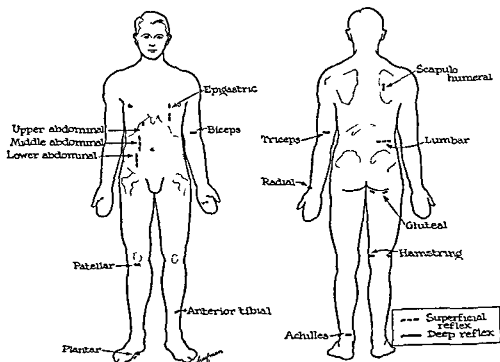


FIG 295—The most important deep and superficial reflexes (Lewin s Infantile Paralysis courtesy of W B Saunders Company)

examinations Gross study of spinal fluid includes color clarity pressure of flow the presence of blood in the fluid sugar reduction the albumin level the Nonne Lange Wassermann and Kahn reactions Microscopic study of the fluid reveals cell composition and the presence of bacteria

Technic for lumbar puncture The patient lies on the right side with the spine flexed The puncture site is usually the interspace between the 3rd and 4th lumbar vertebrae After the skin is sterilized (see Figs 39 and 40) 10 to 15 minims of 1 per cent novocaine solution are injected into it or a piece of ice is used to refrigerate it

Lumbar puncture is also performed for the injection into the spinal canal of such drugs or other remedial agents as serum for epidemic cerebrospinal meningitis magnesium sulfate antitoxin for tetanus and spinal anesthetics When a drug is to be injected as much fluid should be allowed to escape as is to be injected

In Magnus report on 705 spinal injuries, the 1st lumbar vertebra was involved in 193 cases and *this vertebra, and its nearest neighbors* in 131 cases The most frequent combination was involvement of the 12th thoracic and the 1st lumbar vertebra Paralysis was greatest with injury to the 1st lumbar vertebra If improvement is possible the symptoms are due to hemorrhages into the cord substance, or to edema, resorption of which is followed by the re-establishment of free conduction Necropsy studies convinced Magnus that injury to the cord by the fragments of a vertebral fracture caused *permanent paralysis* which could not be corrected by decompression and that when improvement was possible, retrogression took place without operation

Paralysis of the internal sphincter and exposure to view of the posterior urethra and colliculus seminalis were found by Magnus in every one of the 44 cases he examined He concluded that these conditions are positive proof of vesical paralysis following cord injury and that their absence is of value as a negative sign

Lesions of the spinal cord may vary from a complete severance of its substance to a slight concussion, with partial laceration contusion and compression falling between these extremes

Symptoms accompanying spinal cord injury depend upon the level at which the injury occurs and the severity of the trauma

Complete Transverse Lesions —In severe injury to the spinal cord, especially when it is completely divided the victim although conscious is aware of a sensation as if he were suddenly divided in two There is no inherent pain accompanying the division of the cord, although pain at the level of the injury does occur as a result of trauma to the neighboring sensory roots *Immediately after the injury there is complete loss of motor* power and sensation below the level of the injury, reflexes also as a rule are completely absent The muscles are flaccid, the skin is dry and cold and frequently pressure ulcerations and bladder infections occur The bladder and bowel sphincters are spastic so that these structures become distended behind the sphincter Priapism is very common Plantar flexion of the great toes may be absent, visceral sensations are usually absent if the lesion is above the 6th thoracic segment

Partial Transverse Lesions —When the transverse lesion of the cord is not complete the situation is different Immediately after the injury symptoms accompanying a complete lesion may be present due to 'spinal shock Usually even *though flaccidity* and paralysis exist, some sensation is present below the level of the lesion This retention of sensory perception is an important indicator that the lesion in the cord is not complete Even though the lesion is incomplete infection of the bladder and ulceration of the skin may occur and lead to death When extensive injuries of the spinal cord occur even a superficial neurological examination reveals their presence The patient has paralysis and loss of sensation up to a definite level often with distention of the bladder and rectum Roentgenograms of the suspected site of injury may be of considerable help The roentgen examination must not cause additional injury As soon as the patient can be moved without danger one should perform a lumbar puncture with complete manometric determination to determine the presence or absence of

manometer Compression of the jugular vein increases the intraspinal pressure and produces pain in cases of spinal cord tumors

Reverse Queckenstedt Test —In making a reverse Queckenstedt test the pressure is applied from below instead of from above the spinal puncture needle The test is made to determine a spinal block below the level of the spinal puncture

Concussion of the Spinal Cord —Concussion of the spine, according to Sever, *may be divided into four distinct pathological conditions*

(1) A jar of the spinal cord, without any lesion perceptible to the unaided eye, (2) compression of the cord, produced by the extravasation of blood, (3) compression of the cord by exudations within the spinal canal, (4) chronic alteration of the structure of the cord itself

In spite of the apparently free suspension of the cord in the vertebral canal Guttmann called attention to numerous connections between the spine and the cord by which a blow striking the spine is transmitted to the cord and may exert traction or pressure on it The severity of the cord lesion is not dependent on the severity of the spinal injury, as even the most severe forms of injury to the spine, such as dislocation-fractures, may occur without the slightest effect on the cord or its roots Persons who have sustained such injuries are always in danger, because upon the slightest provocation, cord symptoms of severe degree may supervene The average spinal cord concussion, however will begin to show some signs of recovery in twenty four to forty-eight hours if recovery is to be complete or reasonably satisfactory

'Blast' injuries may produce a cord concussion that will not show signs of recovery for at least twenty-one days

The reader is referred to a series of articles on this subject by Pollock, Boshes and their associates

These articles appeared in the following publications A M A Archives of Neurology and Psychiatry, March 1951 A M A Archives of Neurology and Psychiatry Nov 1951 J Neurophysiol, *14*, 85–94 1951 A M A Archives of Neurology and Psychiatry May 1951 J A M A, Aug 25, 1951

Traumatic Lesions of the Spinal Cord —Pollock described a condition of traumatic necrosis of the cord which was seen when a person had a gunshot wound that went through the body close to the cord, producing an inflammatory reaction around the cord with immediate serious symptoms Within five or six days there was noted a recession of cord symptoms, due to the absorption of blood and edema In two three or four weeks sudden complete collapse supervened due to necrosis of the cord

Trauma that did not disturb the spine at the moment has been followed by more or less serious injuries to the cord or its roots Injury to the cord from explosions or blasts belongs in the class of injuries due to the exertion of blunt force on the spine without direct injury to it

Even after the most exact neurological examination it is sometimes impossible to determine whether division of the cord has been sustained or whether the cord or the cauda equina has been merely compressed and not injured too extensively to prevent recovery if the pressure is removed early Hence if operative treatment is delayed too long a reversible cord injury will become irreversible

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Even after the most exact neurological examination it is sometimes impossible to determine whether division of the cord has been sustained or whether the cord or the *cauda equina has been merely compressed* and not injured too extensively to prevent recovery if the pressure is removed early Hence if operative treatment is delayed too long a reversible cord injury will become irreversible

The extent or completeness or degree of the neurological lesion must first be determined. With evidence of a complete lesion which persists for twenty-four hours after injury, Naffziger considers that surgery is probably of no benefit and permanent paralysis is to be expected. In incomplete lesions combined with evidence of obstruction of the spinal canal, appropriate measures should be instituted to restore the spinal canal, or else laminectomy should be done to remove pressure. Judgment of the patient's future in regard to paralysis, is necessary before any decision can be made.

Indications for Laminectomy.—When laminectomy is indicated in the treatment of spinal cord injury, it should seldom be done as an emergency. Only in the presence of complete manometric block which is not relieved by hyperextension, should laminectomy be considered within the first two days after the injury. Even then when the examiner is convinced that a complete transverse lesion exists, no good purpose is served by the operation. For complete block with an incomplete spinal cord lesion, operation should be carried out within twenty-four to forty-eight hours of the accident. For an incomplete lesion in which the symptoms grow worse rather than better and a spinal block develops in the course of weeks or months, laminectomy is also indicated.

While authorities agree that the spine is not weakened by a well performed laminectomy, that procedure should be avoided wherever possible. There is considerable divergence of opinion regarding the static effect following laminectomy. This varies from zero to a high percentage of instability. Laminectomy may be followed by considerable static disturbances, and in some cases by considerable disability.

SPINAL NERVE INJURIES COMPLICATING VERTEBRAL FRACTURE

Nerve injury complicating a vertebral fracture prolongs the period of convalescence and frequently leaves some permanent disability. The spinal nerves may be injured in compression fractures. In the pelvis the lumbosacral cord including the sciatic nerve may be contused. Neurological examination should be repeated every day to determine the extent and progress of the lesion.

When a spinal cord injury is accompanied by fracture or dislocation of the cervical spine hyperextension and traction should be applied to the head. This can be best accomplished with Crutchfield calipers.

For compression fractures in the lumbar region hyperextension with the application of a body cast or a hyperextension frame or bed should be used. Woltman and Learmonth found that an injury to the cord is immediate and irreparable. Extra- and intradural extramedullary hemorrhages are extremely rare causes of compression of the cord. No final estimate of the amount of injury to nerve tissue can be made until the stage of final shock has passed. Operations undertaken during that stage are attended by a high mortality. After the period of spinal shock neurological evidence of complete interruption of the cord is an absolute contraindication to operation. If some conductivity remains in the cord and there is reason to suppose that the lumen of the canal has been reduced by the fragment, exploration is justifiable.

cerebrospinal fluid block. Blood in the cerebrospinal fluid is an indication of the severity of the injury.

Complete Cord Lesions	*Partial Cord Lesions*	*Pressure of Cord from Without*
Sudden onset of symptoms. Immediate and complete symmetrical sensory and motor paralysis	Sudden onset of motor and sensory paralysis. Irregular	Late in onset—few hours. Variable location of motor and sensory paralysis
Muscles flaccid	Muscles often spastic	Muscle tone apt to be preserved
Sensation entirely gone. Sharp line of demarcation	Some sensation present; irregular distribution. No sharp line of demarcation	Very irregular sensory disturbance
Reflexes—knee jerks. Plantar reflex gone entirely	Exaggerated tendon reflexes or irregular	Reflexes disappear slowly and return with relief of pressure
Paralysis of bladder and rectum	Paralysis of bladder and rectum not always present. Dependent on location of injury	Paralysis of bladder and rectum much less apt to occur
Priapism, sweating, involuntary muscular twitchings are common	Priapism, sweating, involuntary muscular twitchings variable	Priapism, sweating, involuntary muscular twitchings much less apt to occur

Immediate Treatment — Transportation of the Patient.—In traumatic lesions of the spinal cord associated with injuries to the vertebral column, the immediate treatment is of the greatest importance. The chief thing to remember is that movements of the body of the patient above and below the fracture of the spine which are not synchronized may produce motion at the point of fracture and increase the injury to the spinal cord. Any person, therefore, who has been injured and who after the injury shows loss of power in the lower extremities or in all extremities except the neck should, in the absence of adequate means of conveyance, be allowed to remain flat on the ground.

If the injured person is to be lifted onto a conveyor of any sort, three or four persons should lift him as a unit to keep all parts of his body in practically the same relation to one another as when he was lying on the ground. A rigid board, shutter or door is the best conveyor to use. If a canvas stretcher is used, especially when there is paralysis of the lower limbs alone, indicating injury to the lumbar spine, the patient should be placed on the stretcher (sheet or blanket) face down in order to avoid an increase of flexion of the spine and further injury to the cord.

After transferring the patient to a hospital, roentgen films should be obtained. It is even more important to avoid rotation of the patient, and particularly the patient's head in relation to his body, for the purpose of such a roentgen examination. With care it is possible to obtain good films without moving the patient unnecessarily.

Occasionally traumatic shock may be present, especially when other injuries exist. Shock should be treated in the usual way with application of warm blankets, intravenous injection of normal saline, transfusion and, if necessary, morphine.

symptoms of spinal occlusion such as increased protein content or xanthochromia of the spinal fluid, a positive Queckenstedt test and in certain cases myelography with iodized oil, should suggest the possibility of a suppurative condition of the spinal cord. The association of a syndrome of spinal compression with fever and leukocytosis makes a tentative diagnosis of circumscribed suppuration of the spinal cord probable and indicates the necessity of an immediate laminectomy.

Dandy pointed out that the usual history of infection of the epidural space includes acute severe pain in the back along the course of the spinal nerves or the legs, followed by paralysis of the lower extremities within a few days after the onset. The pain is due to irritation of the posterior nerve roots. The simultaneous appearance of the sensory and motor symptoms suggests the presence of an intramedullary lesion, while pain appearing several days before the onset of the paralysis is in favor of an extradural lesion. There is profound toxemia. The only method of combating the infection is operation with adequate drainage. Chemotherapy has improved the prognosis very much.

Chronic Adhesive Spinal Arachnoiditis.—Chronic fibrotic or adhesive changes in the spinal arachnoid have been characterized as serous, fibrous adhesive or cystic and as diffuse, disseminated or circumscribed.

In 3 of the 5 cases of chronic adhesive spinal arachnoiditis reported by Mackay the condition was secondary to acute meningitis. Clinically, such cases differ from those of extramedullary tumor of the spinal cord. In the former there is evidence of a diffuse disturbance of the spinal cord and roots, as widely scattered paresthesias and pains, irregular and inconstant sensory disturbances, muscular atrophy and large fascicular twitches, painful muscular spasms, a mixture of exaggerated and diminished tendon reflexes and arrest of opaque oil at multiple levels.

Pathologically there are chronic adhesive or cystic fibrosis and vascularization of the spinal meninges, with injury to the roots and secondary degeneration of the dorsal columns.

Surgical intervention is of value in early stages with only localized arachnoid cysts but may be harmful in advanced stages with diffuse adhesions.

According to Stookey, adhesive spinal arachnoiditis may give rise to spinal cord symptoms that are differentiated only with difficulty from tumors. In his opinion a prolonged history, a positive cerebrospinal manometric reading and a normal total protein content of the cerebrospinal fluid, are the most important diagnostic factors. Roentgen examination is valuable when an opaque substance is seen to be blocked by the tumor. The prognosis is variable, depending on the type of tumor, the duration, location and skill of the operator in removing it. Exploratory operation may take the form of laminectomy or hemilaminectomy. Exploratory laminectomy should be performed when there is a strong doubt as to the diagnosis.

SPONTANEOUS SUBARACHNOID HEMORRHAGE

No condition is more dramatic, more sudden in appearance than subarachnoid hemorrhage. It has been compared to being "struck at the base of the skull." The patient seems perfectly well until seized by a headache

Nursing Care —Whether the patient is operated on or not, the treatment of spinal cord injuries requires, above all, special nursing care This is due to the marked tendency for pressure sores to develop at points of contact of the skin with the bed

MYELITIS

Myelitis (inflammation of the coverings of the spinal cord) may be infectious or traumatic The lesion may be partial or complete There may be paralysis paresthesia and motor and sensory disturbances After complete transverse lesions of the spinal cord not only is there complete motor and sensory paralysis in the region of the body below the level of the lesion but there is also an absence of all reflex activity in the same region *i e* knee jerks ankle jerks abdominal cremasteric and plantar reflexes In addition there is retention of urine and feces Four to six weeks after onset the flaccid paralysis changes gradually to a spastic paralysis which is permanent

DISTURBANCES OF THE LYMPHOID SPINAL EPIDURAL SPACE

The spinal epidural space, as described by Browder, Jefferson and DeVeer extends from the upper border of the dorsal arch of the atlas throughout the length of the dural sac, to merge with the fat-filled space in the sacral vertebral canal In cross-section the epidural space is crescentic and is bounded anteriorly and mesially by the dura mater, dorsolaterally and dorsally by the ligamentum flavum and the segmentally interposed periosteal coverings of the vertebral arches Normally the space does not extend over the anterior surface of the dura since the dura mater throughout its length is loosely attached to the posterior longitudinal spinal ligament The anterior limit of the space is at the lateral border of the posterior longitudinal spinal ligament except at the sites of the dural prolongations about the spinal nerves Here the limits of the space are ill-defined A potential continuation of the space exists between the dural coverings of the spinal nerves and the linings of the intervertebral foramina

EPIDURAL ABSCESS OF THE SPINAL CORD

Epidural abscess is one of the rare causes of an insidiously developing transverse lesion of the spinal cord and may be either acute or chronic It is highly important to recognize that compression of the spinal cord exists in either case In cases of chronic epidural abscess it is extremely difficult to distinguish the symptoms and signs from those caused by a neoplasm affecting the spinal cord Once a diagnosis of compression of the cord is established operation is indicated

Circumscribed Suppurations of the Spinal Cord and Meninges —Suppurative diseases of the spinal cord which are fortunately comparatively rare may be classified as follows (1) extradural (2) subdural (3) intramedullary The diagnosis can be made if the history of infection is kept in mind and careful studies of the spinal fluid are made According to Bennett and Keegan the history of a suppurative process elsewhere in the body the development of a rapidly progressive horizontal spinal lesion presenting

Niles reported 16 cases of herpes for which he used a solution of the pituitary gland. Eleven patients were well in an average of eight and one-half days. He used 0.5 cc. of the solution intramuscularly every other day. Skin vaccination with fluid from the vesicles has also been advocated.

Ormsby recommended sodium iodide intravenously in a dose of 1 gm. the first day and 2 gms. on the second, fourth and seventh days. Roentgen ray therapy and sulfonamides are recommended.

An ergot derivative called DHE-45 appears to control the pain associated with herpes zoster.

In 30 out of 40 cases Combes, Canizares and Simuangco classified the results as satisfactory or excellent. Pain was relieved almost completely after each injection for from eight hours to three days in 17 patients.

The drug is administered by intravenous or intramuscular injection. Intravenous medication brings relief more promptly. If an initial dose of 1 cc. is ineffective, 2 or 3 cc. are given. Some injections are made only for pain. Intervals between doses vary from twelve hours to four days. Side effects are few. The drug does not influence the course of herpes zoster. My experience favors the subcutaneous and intravenous injections of thiamine chloride for prophylaxis and relief. Gamma globulin has been recommended.

PARAPLEGIA

Paraplegia, or paralysis of the lower half of the body, is caused chiefly by infections, tumors and injuries. There are about 2600 military paraplegics in the United States. More than 70 per cent of those treated during and after World War II are engaged in gainful occupations. The important infections are tuberculosis of the spine and infantile paralysis. The injuries involve the brain and spinal cord or vertebrae. Tumors of the spinal cord or vertebrae may cause paraplegia. Sachs described a case of paraplegia associated with a large gibbus, and a localized collection of fat at the site of the gibbus. The bladder and rectal functions are disturbed. The reflexes may be exaggerated, diminished or lost, depending on the location of the lesion. The diagnosis and level of the lesion should be made by the neurologist. Treatment includes supportive measures and physical therapy. Operation is often indicated. The prognosis is always guarded.

According to Kessler, ten times as many cases of paraplegia occurred among the civilian population, from trauma and disease as occurred in the armed services from combat injuries during the four years of World War II. Nevertheless, when one considers the problems of paraplegics, it is the paralyzed servicemen who come to mind. Facilities for the rehabilitation of veteran paraplegics are available.

Nevertheless, one cannot ignore the far larger number of civilian paraplegics. When one investigates their circumstances, he finds that public and private attention has been cursory at best. Facilities are practically non-existent.

This is a great social waste because these people can be rehabilitated. They can usually be taught to walk with the assistance of braces and crutches, and they can invariably be made at least partially self-supporting.

Vomiting, dizziness, stupor or coma may supervene in rapid order, but rarely convulsions Stiff neck, Kernig s sign fever and slight leukocytosis serve to confuse the condition with meningitis

Those persons interested in tabes dorsalis, locomotor ataxia and tabetic neurosyphilis should consult the neurological literature

SYRINGOMYELIA

In syringomyelia some dramatic improvement has followed aspiration of a cyst after laminectomy The differential diagnosis may include a brain tumor

MULTIPLE SCLEROSIS

Multiple sclerosis is " one of the most baffling and devastating diseases in existence " It is characterized by the formation of hard, patchy scars in the central nervous system of the body The currently available evidence strongly suggests that multiple sclerosis exhibits a familial incidence On the other hand multiple sclerosis is too often non familial for a familial, constitutional factor to be its sole cause The disease may be compared to arterial hypertension or diabetes

Mackay believes there is a familial, constitutional vulnerability, to multiple sclerosis This vulnerability is sub clinical and, *per se* inadequate to produce the disease

There is a second non-familial possibly exogenous cause or group of causes which are competent to evoke the disease especially when the first, or constitutional factor is already present

Patients with multiple sclerosis have more fibrinogen in their blood than normal persons

Prolonged rest helps some patients Special exercises are prescribed later Adenosin preparations have been recommended The treatment advised by Jonez for the relief of symptoms of multiple sclerosis combines the work *done by other investigators with emphasis on allergic factors* The histamine therapy was tried at the Mayo Clinic with equivocal results Curare (and its derivatives) was investigated by Schlesigner and others and is still in use by some as a muscle relaxant Physical therapy and rehabilitative methods are being utilized

Sarpyener describes a congenital stricture not associated with spina bifida occulta This pathological entity can be demonstrated by sub-occipital injections of a radiopaque substance It is responsible for many hitherto unexplained clinical manifestations—enuresis spastic or flaccid paralysis and various deformities

HERPES

The physician should always think of incipient herpes in cases of unexplained pain in the legs arms and body with no demonstrable lesion Herpes are analogous to chicken pox of the nerve endings

The following measures have been recommended aureomycin, salicylates per rectum, vitamin B_1, *x*-ray therapy ethyl chloride spray, procaine, efocaine, curare, priscoline, demerol morphine—I-V and alcohol—I-V

The prognosis is determined at the time of the initial trauma, providing reasonable care is taken not to inflict further damage to the cord, by careless handling.

Hyperextension, particularly while under anesthesia, is not advised although it might reduce a fracture-dislocation. The dislocation, if reduced, may recur without further signs of cord injury. Redisplacement is commonly associated with spontaneous anterior or lateral fusion of the vertebral bodies giving rise to excellent skeletal function. An optimistic attitude must be maintained. Careful nursing and physical therapy are helpful.

According to Ryerson, the patient who has a fracture dislocation of the 12th thoracic or 1st lumbar vertebra with a complete cord lesion will probably live paralyzed below the waist until stricken by an ascending urinary-tract infection or an intercurrent disease. Immediate laminectomy should be performed as a routine procedure, especially when the paralysis does not appear instantly.

Fractures with injury to the cauda equina constitute a separate class. The spinal cord terminates at the lower margin of the 1st lumbar vertebra. Below this level the dural canal is occupied by the filaments of the cauda equina. Injuries below the level of the 1st lumbar vertebra are in the category of injuries of peripheral nerves as the elements of the cauda equina are capable of regeneration. In crushing injuries with signs of nerve damage, early operation is indicated. Delay is harmful and long delay may preclude recovery.

Allen advises laminectomy and incision of the commissure within the first five hours. In cases of depressed posterior vertebral arch with fracture of laminae and paralysis the compressing fragments should be removed.

Naffziger recommends early spinal puncture with manometric reading and use of the Queckenstedt test to determine the presence or absence of a block of the canal. If present laminectomy should be done. When complete paraplegia is present the dura should be opened and a small incision made in the posterior spinal columns. Laminectomy is indicated when there are signs of pressure on the cord. In old cases of incomplete cord lesions due to injury, remarkable improvement may follow. In complete transverse paralysis, the value of operation is doubtful. In late cases in which pain persists, a fusion or bone-graft operation should be considered. Jefferson found that damage of the spinal cord was due to instant contusion. Since this injury is irreparable he advised operation. Davis reports a number of cases of partial paralysis which demonstrate that in fracture-dislocations with compression of the spinal cord due directly to jackknifing manipulation into hyperextension is indicated. In industrial areas where severe multiple fractures and complications in internal organs are frequent immediate reduction and splinting are imperative.

In case of a severe fracture-dislocation accompanied by paralysis hyperextension and adequate splinting should precede laminectomy.

Hartwell believes that in those patients who have received other injuries besides the spinal fracture and in those with uncomplicated vertebral fracture, laminectomy is contraindicated for at least four days.

The numerous problems can be solved through the integrated teamwork of specialists

The group of civilian paraplegics presents, in general, a greater complexity of problems than is found among the veteran group

Treatment depends on the lesions and the cause It includes Rest, traction, physical therapy, manipulation, braces, transfusions, and chemotherapy

An outline of treatment of a paraplegic includes

Prophylaxis	Curative measures
Remedial measures	Rehabilitation
Curare	Psychological adjustment
Barbiturates	Tolserol
Thorazine	Tolseram

The essentials in the care of a person suffering from paralysis of the legs resulting from injury to the spinal cord as outlined by Freeman consist of the prompt application of the following points

1 Rotation or flexion of the spine should be studiously avoided
2 The deformity of the spine should be promptly reduced by traction or hyperextension or both
3 The patient must be turned every two hours
4 Proper care of the bladder
5 Proper care of the skin
6 Proper care of the bowels
7 Watch for, prevent and promptly treat anemia, hypoproteinemia and vitamin deficiencies
8 Constantly be on the alert for complicating emotional reactions

A useful guide for achievement is, "What's My Score?" published by the Veterans Administration

PARALYSIS DUE TO FRACTURE OR DISLOCATION OF A VERTEBRA—FRACTURES OF THE VERTEBRÆ WITH SPINAL CORD SYMPTOMS

Spinal cord injury associated with fractures of the spine produces weakness or paralysis of the muscles of the extremities hyperesthesia or hypoesthesia, retention of urine loss of bowel control and arthropathies Priapism is common and is an unfavorable sign

Fracture-Dislocation of the Vertebræ — There is a higher incidence of paraplegia at the thoracolumbar junction than in the lower lumbar region The extent of skeletal damage is no indication of the degree of cord trauma For example Love found that in the thoracolumbar region, a simple interlocking of the articular facets with a minimum anteroposterior shift is often associated with complete paraplegia yet complete displacement must indicate complete transection of the cord In the lower lumbar region however, gross displacement may be present without paraplegia Closed reduction seems to give better results than open, but it is doubtful whether reduction is important

The prognosis is determined at the time of the initial trauma providing reasonable care is taken not to inflict further damage to the cord, by careless handling

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Neri's Sign in Organic Hemiplegia.—*Neri's sign* in cases of organic hemiplegia, consists in the spontaneous flexion of the knee of the affected side as the leg is passively raised while the patient lies supine.

The patient is placed in a recumbent supine position on the examining table. His upper extremities are extended and his forearms are pronated. When his normal forearm is flexed by the examiner, the normal forearm remains pronated but the paralyzed forearm goes into supination.

Significance of Spinal Cord Injury.—According to Speed the cord may be completely destroyed and show no evidence on superficial examination. A break in continuity of the cord may heal by scar tissue, or the torn dura may close over. Improvement after severe injury is explained by the theory that some nerve fibers escaped destruction and resumed function when pressure of edema or hemorrhage was removed. After severe injuries, secondary degeneration occurs both distally and proximally to the area of crushing. Pachymeningitis and death follow.

Course of Bladder and Rectal Paralysis.—When a cord lesion has caused bladder and rectal paralysis the bladder distends and will overflow unless catheterization is performed. Incontinence follows. The retention leads to dilatation of ureters and kidney pelves so that hydro-ureter and hydronephrosis results. Renal and bladder stones may develop even in the absence of infection. These may follow clots or emboli lodging in a damaged kidney or may be due to prolonged recumbency or the precipitation of crystals in the urine following inactivity. Conwell found that 8 patients out of 100 who had sustained compression fractures developed calculi although no cord injury was present. Infection of the urinary tract may be delayed a variable time but when it occurs it spells diaster.

Speed quoted Learmonth, Watkins, Monroe and Hinman who concluded that:

1. Each paralyzed bladder should be treated on sound urological principles.

2. Four effects on micturition must be considered: retention overflow incontinence, automaticity and true incontinence. Automatic bladder never develops as a final effect after fracture below this center; incontinence may follow destruction of the cord at this level. Partial lesions, pressure after trauma, or bruising of the cord cause slight temporary changes. In spinal concussions there is an initial retention. Early automaticity is desirable and some authorities favor its establishment.

3. The skill and precision in execution of the method used determine its value.

4. It is impractical to treat all paralyzed bladders alike. Some do best if left alone, emptied at regular intervals by suprapubic manual expression; others require retention catheters, periodic or continuous (tidal) irrigation; others require cystotomy. If infection is present, choice of treatment lies between an indwelling catheter and immediate cystotomy. The care of the bladder after these injuries should be prompt and precise. Resection of the presacral nerve has been performed to relieve a cord bladder.

Decubitus.—Pressure necrosis from ischemia, local anoxia and loss of the normal protective layer of the skin produces ulcers on the buttocks, thighs or back. Local pallor is followed by redness and later bullae with

vasodilation with pain or anesthesia, if this has not already been caused by the cord lesion These ulcers according to Speed depend on the thickness of padding tissue between the weight-bearing bony prominence and the skin They do not tend to spread rapidly after the first sloughing, if they are given constant attention In some cases of incomplete lesion they heal and later break open again They may become infected from urine and feces, extend quickly and hasten death by septic absorption and exhaustion The sacrum or femora may be exposed and secondary osteomyelitis, dislocation of the hips and meningitis, follow Infection from discharges and prolonged pressure exerts a harmful influence on decubitus trophic disturbances do not Fatal terminations after these injuries may follow septic pneumonia and embolism from the infected surfaces of decubitus ulcers The slightest soiling of the surface must be cared for by washing with simple white soap and powdering The patient's position should be shifted frequently during night and day Zinc peroxide powder can be insufflated if non-aerophilous streptococcus is cultured, or sulfanilamide solution powder or crystals may be used on the surface No dyes or discoloring agents except compound tincture of benzoin should be put on the surface An air bed or sponge rubber mattress is essential for nursing care The bed must be kept dry, clean and free from wrinkles Bactine ointment is helpful

Prognosis

Patients with incomplete cord lesions, who survive the fracture injury and its immediate consequences, may live for many weeks, the course ending with a high irregular septic fever Others live for years finally succumbing to infections spreading from pressure necrosis or kidney infection A smaller proportion regain their reflexes and motor and sensory power beginning with muscular twitchings Some become ambulatory on crutches

A man may live to be ambulatory in a wheel chair without that part of his spinal cord that is below the cervical segments To prevent foot drop, a simple footboard or posterior leg splint is applied The psychological factor supersedes all others

Treatment

Some surgeons recommend skeletal traction through the tibial tuberosities or heels and suspension or elevation of the legs on Braun frames to prevent or treat decubitus ulcers on the sacrum or heels The patient is thus able to lift himself with his own arms to aid in his nursing care The principles of prevention as approved by Spurling are (1) Maintenance of blood serum proteins from time of injury by adequate diet by means of transfusions and by plasma injections (2) Constant dryness of skin areas Use of indwelling catheter and daily enemas to facilitate this Use of penile clamp in the partly ambulatory patient while in bed (3) Use of soft or air mattresses Frequent turning of patient (4) Soap and water, alcohol and powder on skin and on bed sheets (5) Avoidance of adhesive

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Nursing care	Wheel Chair
Morale	Life expectancy
Dependency	Walking expectancy
Narcotics	Job expectancy
Bed Exercise	Parallel bars
Stryker frame	Braces
Entertainment	Walker
Floor Mat	Occupational therapy

Decubiti.—Eighty per cent of paraplegics have decubiti.

Urinary Tract Calculi.—It has been estimated that at least 50 to 60 per cent of paraplegics have calculi. Some have erosion of bone due to malnutrition.

A positive nitrogen balance requires an enormous amount of protein. Hypoproteinemia predisposes to a terminal infection. 5 gms. per cent places the patient in the danger zone. Most of the nitrogen loss occurs in the urine. The hemoglobin must be maintained above 80 per cent. X-rays should be made once each month until the person is ambulatory. Acute medical complications are common. Acute surgical complications involve the genito-urinary and the gastro-intestinal systems.

Spasms.—Pains are problems for the neurosurgeon (ethyl chloride sprays help). Contractures are problems for the orthopedic surgeon.

The paraplegic is a sick man twenty-four hours a day, day in and day out. No one knows this better than the nurse, the ward surgeon, and the medical corps men.

Every person who comes in contact with a paraplegic should be briefed and instructed. The morale of everyone involved must be kept at a high level. This includes the soldier, nurses, ward men, doctors and other attendants such as physical therapists and occupational therapists.

Patient to patient inspiration plus competition is an important factor. Patient to patient stimulus is helpful.

Diet.—"Give him what he likes after he has eaten what is good for him. Try to give him gout." His intake should include:

Hamburgers	Plasma
Beer	Blood
Milk	Vitamin C
Eggs	Vitamin B
Lobster	Thiamine
Malted milk with amino acids	Riboflavin
Steak	Niacin
	Folic Acid

If one stops to reflect, he will realize there are only four kinds of treatment:

1. Medical
2. Surgical
3. Physical
4. Psychological

The paraplegic might need one or all—day and night.

tape application to areas likely to undergo ulceration (6) Eternal vigilance for first signs of induration or redness over bony prominences

Principles of treatment of existing open bed sores All of the principles of prevention apply doubly strong to the open bed sores In addition may be mentioned (1) Use of drugs locally and by mouth (2) Avoidance of further compression wherever possible (3) Assumption of sitting posture where possible (4) Early skin grafting of granulating areas

My most extended experience with paraplegics goes back about forty years During the period from 1909 to 1944 I observed and studied about 50 cases I saw very few during World War I However, during World War II in 1944 at Mayo General Hospital we had 88 paraplegics at one time

In a panel discussion at a meeting of the American College of Surgeons with Dr Herman Kretschmer as the moderator and Drs Mayfield, O Heeron Krusen and Lewin as panelists I said

The paraplegic presented a complex problem requiring

1 The precise coordination of highly trained personnel
2 Special equipment
3 Morale builders

The paraplegic presented a unique problem—it was a military problem as well as a medical problem The neurosurgeon came first He tried to undo the primary damage His services would be worthless unless the urologist could prevent or control a fatal infection of the genito urinary tract And so far as the soldier was concerned nothing was of any consequence unless he could be made to walk again

The paraplegic wanted to know Will I ever walk again? He refused to 'settle for less If I will never walk again all the experts are wasting their time on my bladder

It is a tragic sight to see a boy in the bloom of youth and the acme of physical development suddenly—yes—in the twinkle of an eye—reduced to a vegetating mass with perhaps nothing left but a good mind which *wonders* day and night, but only occasionally *asks* What is the score?' and Will I ever walk again?

In a few minutes a wonderful boy—who is the flower of the crop—has been transformed into a man who repeats to himself over and over 'Whither am I—whither am I *not* going? Or Am I going to wither?

It has been said that an animal is a motorized plant If this is reasonably true we are hereby confronted with the problem of a demotorized man

About 75 paraplegics were sent to each center in the United States At Mayo General Hospital at Galesburg Illinois 100 persons including doctors, nurses medical corps men and women Red Cross workers and dieticians entered the paraplegic wards every day to work

Cost of Care of a Paraplegic —Dr Kennedy figures the cost per patient as $7 000 the first year $5 000 the second year

Let us compare this with poliomyelitis Mr Basil O Connor President of the National Foundation for Infantile Paralysis estimated the cost of treatment of one patient at $1 200 to $2 500 a year

Some important factors include

There is no doubt that it helps to balance nitrogen metabolism. Moreover it minimizes the tendency to the formation of renal calculi.

Studies on normal men carried out at the New York Hospital indicates that the oscillating or tilting bed offers certain advantages to therapy during prolonged immobilization. It modifies the changes in circulation and calcium metabolism brought about by immobilization. There was some evidence of a beneficial effect upon the protein and creatin metabolism and muscle atrophy.

THE CATABOLIC EFFECT OF TRAUMA OF THE SPINAL CORD AND ITS TREATMENT WITH TESTOSTERONE PROPIONATE

Cooper and associates found the maintenance of adequate nutritional status to be one of the most difficult problems in the management of severe injuries to the spinal cord. Depletion of protein associated with rapid decrease in the value for serum proteins, precipitous loss of weight and early development of decubitus ulcers are serious problems. They prescribe testosterone propionate as an anticatabolic or nitrogen sparing agent.

The Relation of Spinal Cord Disease to Gynecomastia and Testicular Atrophy.—Mammary enlargement and testicular atrophy have been observed among young men who have suffered severe injury to the spinal cord. There may be a causal relationship between injury to the spinal cord and the subsequent development of gynecomastia in some paraplegic men. Although gynecomastia and testicular atrophy have previously been reported, secondary to traumatic lesions of the spinal cord, Cooper and his associates observed patients who had these two conditions associated with degenerative lesions of the spinal cord.

Urological Complications in Spinal Cord Injuries.—An important factor in the successful treatment of spinal cord injuries is a careful watch over the bladder. When catheterization is required more than twice some surgeons institute the tidal drainage system of Munro. This should be entrusted to a trained urologist. Some authorities advise cutting the first sacral nerve.

SURGERY

There is an important surgical phase of the problem which I shall merely enumerate.

To Correct

1. Adduction of thigh
   - *a* Intrapelvic obturator neurectomy
   - *b* Adductor myotomy and anterior obturator neurectomy

2. Internal rotation of thigh
   - *a* Durham operation. Gluteus medius and Gluteus minimus
   - *b* Supracondylar derotational osteotomy

There has never been anything in medical history comparable to the chapter of the paraplegic especially as it was written during World War II It was the greatest clinic of all time The *paraplegic team* was "in there pitching all the time"

Aids to Locomotion and Recovery of Muscle Power —The best aids to locomotion are human and mechanical They include

Leg braces	Walkers
Spine braces	Attendants
Crutches	

Many clever mechanical means of assisting locomotion have been designed Lowman designed a suspender apparatus to raise the diaphragm and the shoulders He used rings, hooks, straps and pulleys Appliances are helpful both in bed treatment and in out-of-bed treatment and during attempts at ambulation Walkers are of the greatest aid In laminectomy cases, casts, splints and braces are indispensable Automobile adjustments are made in the factory

The latest aid for these unfortunate persons is the simple motorization of wheel chairs

THE COMPOSITION OF A MILITARY PARAPLEGIA TEAM

1 Neuro surgeon
2 Urologist
3 Nurse
4 Dietician
5 Ward surgeon
6 Medical corps man
7 Red Cross worker
8 The paraplegic himself
9 Other improved paraplegics
10 Neurologist
11 Internist
12 General surgeon
13 Neuro psychiatrist
14 Chaplain
15 Roentgenologist
16 Laboratory worker
17 Pathologist
18 Plastic surgeon
19 Orthopedic surgeon
20 Brace maker
21 Physical therapist
22 Occupational therapist
23 Physical instructor
24 Social service worker

The greatest risks of life arise from decubitus ulcer and complications incidental to impaired function of vesical and anal sphincters Chemical and antibiotic therapy reduce the danger from infection The contributions of the physical therapist and the urologist to the care of these patients deserve great emphasis

The paraplegic soldier has lost more than anyone realizes My thesis is *For Him the War is Never Over*

There were 1 400 paraplegics returned to the United States during World War II They were transported to 20 neuro-surgical centers Seventy-five per cent had decubiti on arrival Every patient was turned every one to four hours

The Oscillating Bed —Barr made important observations regarding the oscillating bed It is a rocking bed that keeps the person and his tissues in a state of agitation

rongeurs to within a short distance of the articular facets The lamina above or the one below, or both, are also resected if they are pressing on the cord Adequate exposure and perfect hemostasis should be obtained before the dura is opened After incising the dura, subdural hemorrhagic clots are removed and the spinal cord is inspected through the arachnoid If amply justified, the cord may be opened Dislocations or displacement of vertebra may be reduced at this time by traction and manual force

After treatment —If the dislocation of the vertebra has been reduced the patient is placed on a Bradford frame covered with an air mattress Compression of the vertebra may be corrected immediately by means of a Rogers frame or may be deferred for two weeks In either event at that time a hyperextension body cast is applied and retained for a period of eight weeks The utmost care must be enforced to prevent respiratory abdominal and urinary complications and expert nursing attention is necessary to preclude the development of decubital ulcers

The prognosis of spinal cord injuries is always doubtful and frequently discouraging As the operative risk from laminectomy is negligible however, particularly in the lower portion of the spine, laminectomy is worthy of trial if there is the slightest possibility of material relief

Paraplegia Associated with Non-tuberculous Kyphoscoliosis —Pressure paraplegia may occur as the direct result of angulation of the spinal cord secondary to severe kyphoscoliosis The paraplegia usually appears after many years The paralysis spastic in type is associated with sensory changes below the point of compression with sphincter weakness but rarely with pain The block in the pathway of the spinal fluid may be demonstrated by pressure studies and by the injection of pantopaque Some patients are relieved by hyperextension of the spine but most require surgical decompression of the impinged spinal cord at the point of maximum angulation of the spine

If signs of cord compression appear in a patient with non tuberculous scoliosis that compression is usually due to a spinal cord tumor spondylitis abscess trauma or a superimposed disease like syringomyelia Zanoli found only 12 cases on record of the spinal syndrome associated with severe scoliosis of the thoracic spine He added 2 cases Viets and Clifford report a case in which paraplegia developed from mechanical compression of the spinal cord by scoliosis They found reports in the literature of 17 cases The clinical symptoms results of the examination of the spinal fluid and the findings of myelography and operation show that the myelitis is caused by compression it may also be proved by laminectomy in cases which are not too far advanced Sachs reported a case where the paralysis was caused directly by deformity of the spinal canal In the diagnosis it is necessary to rule out intra- and extramedullary tumors and tuberculous spondylitis Tumor is ruled out by the continued absence of pain and the symmetrical distribution of the spinal symptoms

Hyperextension of the spine on a convex frame is the most conservative method of treatment By using the Rogers bed the hyperextension can be increased from time to time up to the point of maximum convexity Results are good in about one half of the cases the patients who do not do well after a few months usually need operation

3. Flexion of hip
   a. Soutter operation
   b. Campbell operation

4. Flexion of knee
   a. Wedge plaster casts
   b. Hamstring lengthening
   c. Hamstring transplants
   d. Patellar advancement
   e. Capsullotomy

5. Foot defects
   a. Popliteal neurectomy
   b. Tentomy
   c. Arthrodesis
   d. Plastic wedge resection

1. Lower extremity
2. Upper extremity
3. Trunk

a. Bones
b. Joints
c. Muscles
d. Tendons
e. Nerves
f. Skin
g. Fascia
h. Fascial transplants to compress bladder
i. Plastic surgery

Operations on Nerves.—Operations on nerves include the Stoeffel or Foerster procedures Rhizotomy and Cordotomy. Cordotomy is performed for pain only.

LAMINECTOMY

The course of the clinical progress of the patient is very important. If the paralysis is complete immediately *do not* operate (although there is nothing to lose). If the paralysis is progressive—*operate* immediately. The determining factor is not the degree of paralysis but evidence of a progressive lesion.

Laminectomy may be performed several days after a spinal injury, although the efficacy of the procedure is debatable when an immediate complete physiological block follows the injury. It is the consensus of neurologists that it is worthless. If the block is of six weeks' duration or more a laminectomy is of practically no value.

Campbell's Technic.—A curved incision 5 inches in length is so placed that its center will be over the affected vertebra. Two spinous processes proximal and distal to this vertebra should be exposed. To prevent hemorrhage, the soft tissues are stripped subperiosteally from the spines and laminæ. Sharp dissection is used on the fractured process. In addition the fragment should be grasped with an instrument and constant traction applied so as to protect the cord. The spine and laminæ are removed with

the cause of the paraplegia The benefit from operation was due to release of tension on the spinal cord by the tightly stretched dura They introduced the use of polyethylene film over the exposed cord at the time of the wound closure

Flaccid Paraplegia —Hunt and Cornwall regard flaccid paraplegia of two corresponding extremities as the antithesis of spastic paraplegia At the onset the paraplegia may be flaccid, from many causes, of which the most common are (1) section of the cord from direct trauma, as in a bullet or stab wound, (2) compression as a result of fracture or dislocation, spondylolisthesis, extramedullary neoplasm or hemorrhage, (3) infections tuberculosis, syphilis, poliomyelitis, malaria, septic meningomyelitis and abscess, (4) simple degeneration or myelomalacia, accompanying diseases of the hematopoietic system and thrombosis, (5) exogenous toxins, lead or alcohol (6) an unknown source, as in Landry s disease, and (7) a congenital defect Early flaccidity may terminate in residual spasticity, depending on the location of the lesion in an upper motor neuron

Laminectomy is the treatment of choice in some cases but should be used only after a trial of conservative methods Tension of the spinal dura at the point of maximum angulation is nearly always found with a pad of fat covering the spinal cord in the same area The dura should be left open after decompression of the cord A few brilliant results of operation have been reported

Scoliosis and kyphosis with paraplegia, excluding spinal deformities due to tuberculosis, is rare Forty-one cases of this type have been reported In the case of Gulledge and Bray the kyphotic element was the predominant deformity, whereas in the great majority of cases the scoliotic element was

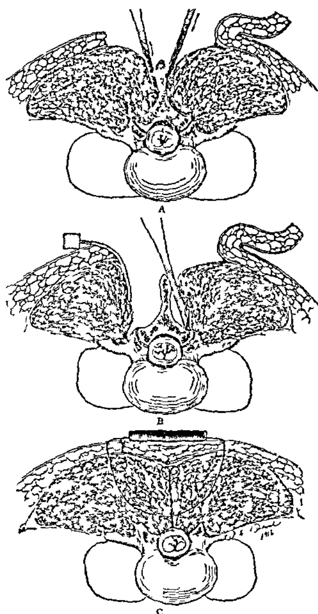


Fig 297 —Incision and closure in laminectomy *A* Separation of the muscles from the tip of the spinous process *B* separation of the muscles from the laminæ as far as the articular processes *C* closure (Frazier Surgery of the Spine and Spinal Cord courtesy of D Appleton and Co Publishers)

Mental Stability —It was learned by bitter experience that the mental stability of the patient should be evaluated and found satisfactory, prior to elective surgical treatment of the back. Willien stressed this point when he stated, "The emotional stability and personality of the patient are as important as the organic pathology, in considering the treatment or disposition." When a back was so securely locked that it would not respond to gentle or moderate manipulation, there was no choice but surgical intervention. However, in the vast majority of instances the operation was deferred when either mental instability or a frank psychoneurosis was present. In many instances soldiers needed considerable superficial psychotherapy preoperatively, particularly reassurance. Many psychologic problems were prevented by the proper mental preparation of the patient for surgical treatment. Undue apprehension preoperatively had many explanations. Often a soldier had previously been advised to "never let a surgeon stick a knife in his back."

Superficial psychotherapy was needed postoperatively in many instances. Psychologic problems occasionally developed during convalescence.

The secondary gain to the patient from illness, proved to be a powerful force and had to be counteracted in emotionally unstable persons by vigilant reassurance and a firm hold on the patient's confidence. Prevention proved to be the brightest ray of hope for effectively dealing with this important aspect of the problems in the military services.

Specific Psychogenic Symptoms Related to the Back —Specific psychogenic symptoms related to the back that were observed in relation to suspected lesions of a disk are (1) "giving way"—this was a favorite neurotic symptom. Rarely did the patient fall or injure himself and there were no associated objective observations of the muscles or the back. (2) hysterical fixed extension—the patient walked with the back rigidly extended presenting what was described by a psychiatrist as a "ceremonial gait"; full flexion was possible whenever the patient was not walking. (3) hysterical flexion—the patient walked with the back in partial flexion, resembling the hysterically flexed spine of camptocormia; and (4) exaggeration of existing organic symptoms: this frequently was confusing when symptoms from a lesion of a disk were known to exist; only a broad background of experience proved to be a satisfactory basis for estimating where the organic aspect ended and the psychogenic factor began. An anxiety or tension state frequently was found responsible for the magnified symptoms. A long skin scar tended to cause more psychogenic magnification than a short scar.

When a back was a focus of neurotic symptoms the following observation was often made. As the back was passively flexed, resistance was encountered after a few degrees and the patient would contend that the back could not move farther. However, with firm steady pressure it would move slowly and jerkily through a normal range of flexion and extension. This observation was in striking contrast to the condition observed when a spine was limited in flexion by an organic lesion. When substantial resistance and pain are met in the process of passively flexing the back with an organic condition, there is progressively increasing muscle spasm and seldom can the patient tolerate more than a few additional degrees of flexion.

CHAPTER 41

TRAUMATIC NEUROSIS IN RELATION TO BACK DISORDERS—WAR NEUROSIS—COMPENSATION NEUROSIS

PSYCHOLOGIC ASPECTS OF BACK DISORDERS

THE psychologic component in disorders of the back is being accorded more recognition in scientific medicine than ever before.

Many nonmedical men by various manipulations, effect relief in persons who had previously sought the advice of medical men. In these instances, the benefits of treatment and even the alleged cures are accomplished by procedures that are essentially mechanical or physical in application but to some degree psychologic in effect.

The inter-relation between the physiologic and the psychologic aspects of disorders of the back are important.

Recognition of the importance of the psychologic factor, has grown into an intensive one with observations being carried out on the problem of the relationship between psychologic and physical factors in physical treatment.

The most powerful motivating forces in human behavior arise from that part of the personality termed the "unconscious."

If the physician treats the disease without reference to the psychologic needs of his patient, he may meet passive indifference or even active opposition on the part of the patient.

If on the other hand, the physician recognizes and ministers to the psychologic needs of the patient, the latter himself will often find the cure. This is more apparent in such illnesses as conversion hysteria where the psychologic elements predominate.

Careful and intensive observation of the person under consideration will do much toward the formulation of an opinion. One should attempt to discover what the person has at stake, i.e., what does he have to gain by his actions or complaints?

Psychogenic Orthopedic Symptoms in the Army Air Forces During World War II.—During World War II the back was repeatedly found to be the focal point of psychogenic symptoms. These symptoms represent (1) a perpetuation of symptoms from a healed organic lesion, (2) an exaggeration of existing organic symptoms or (3) a conversion hysteria without an associated organic lesion either in the present or past.

Luck, Smith, Lacey and Shands relate that a psychologic history was taken whenever symptoms of the back were bizarre and out of proportion to the physical observations. The physical examination often included a check for the presence of hysterical sensory changes (circumferential hypalgesia).

There are back conditions that permit a man to work (and often do hard manual work, with protection) but which become disabling under basic military training or battle action These conditions are listed as I P T I, meaning they existed prior to induction and are aggravated by military service

Battle Fatigue —This is characterized by restlessness, mental fatigue due to physical bombardment, physical fatigue, sleeplessness and apprehension The cure involves removal from the battle area, warm desirable food, adequate sleep and the opportunity to have a clean body and clean clothes The outlook is favorable within a short period without danger of residual trouble Most of these soldiers are not only not more vulnerable to recurrences but they usually are more resistant to future trouble

Neurosis is defined by Fetterman as "A disheartened reaction to a physical or social reverse," which means an exaggerated response to illness, bodily injury or disease, real or anticipated

A traumatic neurosis has been defined by Herndon as a combination of symptoms referable to the nervous system, which follow an injury, but which are not the result of organic lesions

The term "compensation neurosis" implies the fact that compensation quickly terminates the period of idleness

"A traumatic neurosis is a psychogenic, non-structural nervous complex following a physical injury" Neurasthenia is characterized by abnormal fatigability and exaggerated irritability A neurasthenic is quickly exhausted, physically and mentally

Occupational neuroses generally represent hysterical conversion phenomena in which the patient cannot perform certain complicated acts learned by experience, despite the fact that his muscles and their innervations are normal and other voluntary activity is possible

The term "traumatic hysteria" should be limited to the compromise, conversion reactions of maladjusted persons, with personality and character defects often associated with the physical disorders which follow injury Traumatic neurosis is a convenient term which has hypnotized and misled judges and juries Meyer found that at least 25 per cent of the cases of traumatic neurosis that got into court were pure simulation

Exaggeration means exaggeration of an organic or functional disturbance Malingering however means simulating disease or disability A malingerer is dishonest In malingering there is a marked difference between what the surgeon believes and what he can prove

Malingering —A malingerer is a willful imitator of disease for the purpose of gain Babinski said that there is only a moral difference between the manifestations of fraud and those of hysteria Thus in hysteria the patient is not aware of the dishonest motive behind his symptoms while the malingerer is The manifestations of neuroses are hysterical neurasthenic and hypochondriacal in character The fundamental condition is a disorder in conduct occurring in persons who are fearful and dissatisfied and who seek compensation for something that is not due them or who try to obtain relief from certain obligations The greatest difficulty arises in differentiating a true neurosis from malingering

War neurosis includes many varieties of conditions exhaustion neurosis shell shock, concussion neurosis, fright neurosis and neurocirculatory asthenia The majority of symptoms are true hysterical conversion phenomena These consist of tremors, astasia-abasia, blindness, paralysis stammering, aphonia and many others

TRAUMATIC NEUROSES

Compensation neurosis	Railway spine
War neurosis	Industrial neurosis
Post-traumatic neurosis	Neurasthenia
Hysteria { Anesthesia, Paralyses }	Functional states
	Exaggeration
Psychoneurosis	Malingering

From my experience and observation during basic training and battle action in World War I* and basic training during World War II, I cannot subscribe to the statements that war neuroses are no different from compensation neuroses *or that there is no such thing as war neurosis per se*

The big difference in war is the inevitable realization of individual and mass injury and destruction If a man is off duty from civil work, only he and his associates know it If a soldier is killed in action the news may be broadcast and his picture might appear in the hometown newspaper

Certain general remarks, basic principles, signs and symptoms are common to most cases There is always a background, a combination of circumstances, *incompatibility of subjective complaints and objective* findings (or at least, a disproportion between them) and negative roentgenograms

Fear + No physical avenue of escape = Hysteria

One good look at the person under consideration will do much toward the formulation of an opinion One should try to find out what the person has at stake What does he have to gain by his actions or complaints?

The line officer must be on guard at all times to recognize the signs of an epidemic that might break out in his organization

The functional disorders of the back following injury "In Line of Duty" are

I Gold bricking
II Legitimate—battle fatigue
III Traumatic neurosis
IV Exaggeration
V Hysteria
VI Malingering

* In World War I I was a member of the disability board at Camp Grant Illinois President of the disability board at Camp Taylor Kentucky and a member of the classification board at the classification camp of the American Embarkation Center Le Mans France

To the orthopedic surgeon the most important functional neurological condition is **traumatic neurosis of the back** McKee noted two events which greatly stimulated interest in the neurological aspect of injuries World War I produced a wide variety of anatomical and functional nerve injuries and the introduction of workmen's compensation laws brought functional nerve injuries into the limelight Even a well-meaning worker might have difficulty in dissociating his actual symptoms from symptoms born of a conscious or unconscious desire to obtain what he thinks is his due for an injury Actual trauma to some part of the nervous system complicates the difficulties of diagnosis The physician cannot always be certain which symptoms are the result of the anatomical injury sustained or of a psychic disturbance Working unaided the neurologist, psychiatrist, or orthopedic surgeon cannot aid such patients sufficiently Psychotherapy may have to be combined with physical therapy under orthopedic management Relief from an organic lesion will often cure a functional disorder

According to Riley the object of all functional disorders is the desire of the patient to get something which he is unable to obtain by other means It is a defense mechanism brought into play against a hostile environment Often the situation resolves itself into a simple equation, *i e*, desire + inadequate resources + normal health = failure, whereas desire + inadequate resources + abnormal health = success All persons who are recognized as malingerers or neurotics show a definite discrepancy between the symptoms complained of and the anatomical and clinical findings present Magnuson called attention to the fact that it is impossible for a malingerer to stick to the same story during three or four examinations He devised a pressure meter by means of which the physician goes over the entire back and marks the areas complained of by the patient In between the various examinations he examines the reflexes, looks at the throat and examines the teeth in order to divert the patient's attention from the alleged back pain Then he makes another examination of the back If the man has real pain in any one spot he knows that spot every time it is touched The malingerer will tolerate different amount of pressure at each examination

While in the majority of cases pain is attributable to an obvious organic cause, in some the severity of the pain and its persistence appear to be out of proportion to the organic lesion, in others no organic condition can be detected

Hysterical conditions constitute one branch of functional lesions Charcot recognized that hysterical arthralgias simulate closely organic arthropathies In civil practice most cases of functional disturbances of the back occur in females In military and industrial work most cases occur in males

Arthropathy involving the back may be the first manifestation of hysteria Functional arthropathy of the back often follows a slight trauma associated with emotional shock

Hysterical pains may be ' neuralgic migrainous or rheumatic ' and occur anywhere in the head body or limbs The patient often speaks of them as terrible ' but generally shows a certain detachment, if not indifference Pain in the back is a common and persistent complaint It may be diffuse

A person who is suffering from a neurosis will try to corroborate his subjective symptoms by some objective signs of disordered function These signs may be divided into five groups (1) poor general health as evidenced by weight-loss, flabby muscles sallow skin, anemia, and general weakness (2) increased excitability of muscles and nerves as shown by the presence of tremors and increased tendon reflexes (3) disturbances in the realm of the autonomic nervous system such as palpitation tachycardia flushing sweating and other vasomotor abnormalities, respiratory irregularities and gastro-intestinal disturbances (4) sleep disturbances, (5) certain psychic disturbances the most frequent of which are general irritability, dispositional depression, fear states and phobias A social diagnosis is often as important as a medical one

Schaller and Somers discuss the psychogenic factors and precipitation point in **post traumatic neurosis** The psychic factors are those of litigation and the desire for compensation These cases on analysis yield a surprising number of other adverse mental complexes and influences, among which may be mentioned mental shock or fear states poverty deformities lack of occupation or interest unfavorable suggestion including the possibility of serious disability because of continued compensation combined with introspection and meditation incorrect diagnosis improper or unskilled treatment desire for redress against alleged negligence marital difficulties bereavements unfavorable environmental influence or return to arduous or undesirable work

A characteristic of post-traumatic neurosis is the striking discrepancy between the claimed occupational inefficiency of the patient and the absence or paucity of demonstrable physical manifestations and objective signs of disability Post-traumatic neurosis may be identified by a precipitation point which develops at an early period This point may be recognized by a period of negative departure of efficiency by a climax of adverse mental influences occurring after meditation and by the usual symptoms and signs of psychoneurosis At the precipitation-point the complication of psychoneurosis enters as a new factor of industrial disability and compensation When established post-traumatic neurosis runs a long course and is resistant to treatment In traumatic hysteria especially in women by the time a lawsuit is settled contractures may have developed and may require surgery

All patients with traumatic neuroses have one point in common their symptoms do not fit the anatomical or pathological findings Each person displays the symptoms he believes should result from the injury he received This may be done subconsciously for not all these patients are out-and out malingerers One of the most difficult tasks in the practice of traumatic industrial and military medicine is the evaluation of the emotional background and the psychological reaction of the patient to his present situation

Few of these patients have their **compensation neuroses** when they reach the doctor they acquire them under his supervision The inference from this places a serious responsibility on the shoulders of the medical profession By far the most valuable single factor in curing these neuroses is the lump sum settlement contract which gives the individual an adequate amount of money in one payment with his absolute agreement that this closes the case

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Hartenberg found that the basis of hysterical personality is excessive imagination In most cases of functional arthropathy there is an interval of contemplation and auto-suggestion between the trauma and the appearance of symptoms In spinal hysteria there is a disproportion between the symptoms and complaint and the physical findings Roentgenograms may offer conclusive negative evidence Before a diagnosis of hysteria is entered, complete physical and neurological examination should be made so that no organic lesion may be overlooked

Social reverse represents all the failures of the ego in contact with others serious business losses, disappointments in love and other attempts which have not reached their goal The mental reverse is the inciting cause of the neurosis

Wechsler said, "Every normal person is a little neurotic and every neurotic quite normal " The chief characteristic of the potential neurotic is an emotional type that has a hypersusceptibility to "nerves," usually inherited Overwork and intoxication of any kind may produce a neurosis without the element of previous inheritance The psychoneuroses require a favorable soil for their development This is furnished in a large percentage of cases by unfavorable heredity, and by such various types of physiological deficiencies, as dietary or endocrine imbalance or pre-existing disease

In every case of psychoneurosis, one must obtain data from all possible sources as to family history, personality development and the presence of peculiar traits The chief symptoms of neurosis represent a replacement of security and hope by fear and of calmness by anxiety They include sleeplessness, palpitation and tremors The victim seems to have lost an objective interest in the life around him His mind is centered within himself He believes he must make his symptoms stronger to get more sympathy He listens to his arteries beating, he can feel the blood coursing through his veins, he can experience the pounding of his heart against his chest wall, and he becomes attentive to the rumblings in his abdomen When these hitherto unknown sensations reach consciousness in the already alarmed and suggestible mind they are misunderstood, and each sensation is looked on as a new disease or as an ill omen of approaching disaster The patient centers his attention on the injured area The resulting symptoms may vary from aches and pains to hysterical blindness and paralysis When the condition becomes advanced, psychotherapy is indicated, Fetterman suggested a ' transfusion of ideas ' One must infuse cheer to replace the fears, and exchange confidence for worries The patient must be won over by the doctor s sincerity and by a thorough physical examination When litigation is a factor these persons invariably show the stigmas of hysteria Analysis reveals the injury as often a minor factor in the whole syndrome Some authorities believe that the desire for compensation is the sole and all-important feature, and that without this element of gain there would be no traumatic neurosis

Freud's interpretation was that neurosis is a flight from reality The trauma provides an opportunity enabling the patient to find in the neurosis a defense for his failure The incidence of this condition according to Neuhaus, is increasing in proportion to the increase of industrial, automobile and other injuries Athletic injuries rarely lead to traumatic neurosis

or localized in one spot The hysterical back is held in an unusual attitude usually with no organic cause for the position It should be treated by suggestion, support, retention in the proper position with plaster-of-Paris if necessary, exercises, massage, contrast baths, injections, and in rare cases by incision of the skin and suture The back pain may be severe and accompanied by muscular rigidity and curvature of the spine This typical hysterical forward bending of the spine is known as "camptocormia" and often follows trifling injury to the spine After a time it tends to become an hysterical contracture, the patient walking with his body bent forward almost to a right angle, and the head turned upward The hysterical pain may be limited to the tip of the coccyx Pain in any part of a limb may be accompanied by peculiar dysesthesias and paresthesias and not infrequently by contractures Hyperesthesia is a common symptom, the extreme tenderness being entirely out of proportion to the immediate stimulus Localized hysterical tenderness has given rise to the conception of hysterogenic zones which were formerly made use of, either to elicit or to cut short an hysterical attack These local tender points are generally found in various regions of the spine, the breasts, epigastrium inguinal regions or the head

Diminution of sensation is more common than hysterical anesthesias These anesthesias are not limited to typical neural distributions but involve a limb or part of a limb glove and stocking" half of the body or the mucous membranes All forms of deep and superficial sensation are involved, without that dissociation which often occurs in organic sensory disturbances If the anesthesia is confined to one-half the body, it is found to stop exactly in the midline, which is contrary to normal cutaneous nerve overlapping Moreover contrary to organic loss of sensation the anesthesia often disappears as suddenly as it came not infrequently as the result of auto- or hetero-suggestion

Hysterical paralysis may be partial or complete, flaccid or accompanied by contractures Generally it involves half of the body a limb or part of a limb a function rather than a muscle or group of muscles innervated by certain nerves The hysterical person makes no effort to move his back or legs, he is psychically indifferent to it There is no atrophy, at least for a long time no loss of reflexes and no reaction of degeneration Pains occasionally accompany the paralysis After a time contractures appear and are often severe **Hysterical hemiplegia** is generally flaccid, the patient dragging the leg rather than spastically circumducting it as does the patient with an organic lesion **Hysterical astasia abasia** is the inability to stand or walk despite the normal ability to move the legs when lying or sitting With stasiphobia the patient is seized with anxiety if he is made to walk clutches for help and crumples up when his support is taken away The hysterical gait is nondescript bizarre or pseudo-ataxic the legs being flung in all directions Some patients are able to crawl swim or run but not walk The deep and superficial reflexes in hysterical paralysis are generally exaggerated Pseudoclonus is sometimes present but there is no true Babinski sign Paraplegic contractures torticollis, trismus kyphosis scoliosis or lordosis may also occur After prolonged duration they may become permanent but in the beginning they disappear during hypnosis or general anesthesia

the present time "railway spine" is due to accidents by automobiles more frequently than by trains

Unexpected strains while lifting, falls from heights, cave in accidents and other forms of industrial injury are common causes

The pain and tenderness vary greatly in intensity in different patients in the same patient at different times, and in different areas of the same patient The pain is described in its milder forms as a burning, an aching, soreness, or the sensation of "pins and needles", in severer forms as shooting, stabbing constricting, distending, pulling or drawing, and in its rare but most acute form, as agonizing, vise-like, tearing or rending

PAIN

Pain—"a form of consciousness characterized by the desire of escape or avoidance" —Webster (Quoted by Joseph Barr)

Pain is a very elusive phenomenon It often comes from "no one knows where and disappears from no one knows what

The phenomena of pain belong to that borderland between the body and soul, about which it is so delightful to speculate from the comfort of an armchair, but which offers such formidable obstacles to scientific inquiry (Kellgren) Remember that pain has this most excellent quality If prolonged it cannot be severe and if severe it cannot be prolonged (Seneca, Epistles) Pain is purely subjective It cannot be measured or photographed or reduced to mathematical equations Indeed one may wonder if it is at all accessible to scientific inquiry (Kellgren)

Because of the psychological factor pain cannot always be accurately evaluated or interpreted This fact is important from many points of view including medico legally In the last analysis one can understand pain only in terms of his own experience with this sensation

Pain in the limbs may be caused by disorders involving any of the structures or tissues of the extremities, or by disturbance elsewhere with the sensory phenomena referred to the limbs Pain tends to reveal the point from which it arises by certain qualities and by its location The nature of the pathologic process resulting in pain may be mechanical chemical thermal, toxic, nutritional metabolic circulatory, or may involve combinations of these categories The type of pain, its distribution and the associated clinical phenomena yield important clues as to its cause

Fracture dislocation of vertebral bodies herniation of a nucleus pulposus and calcification of the ligaments of the spine are frequent causes of pain in the arm and leg The mechanism of production of this type of pain has been demonstrated by Kellgren It appears to arise from irritation or disruption of nerve fiber endings in the ligaments about the vertebral joints The interspinal ligaments are innervated in a segmental manner Irritation of them stimulates the posterior division of a spinal nerve, and pain is produced in an extremity as a manifestation of referred pain In many instances there are peripheral areas of hyperalgesia and hyperesthesia associated with skin changes suggestive of an antidromic effect that is impulses passing peripherally via a sensory nerve

Traumatic neurosis is just as likely to follow a slight as a serious injury The chief factors predisposing persons to psychoneuroses are personality defects, pre-existing hysteria or some intolerable situation, economic distress, a standard of living just over the borderline from despondency, domestic conflict, "frustration" and monotonous work, with insufficient periods of rest, recreation and diversion

Osnato stated that the essential feature motivating the emotional reaction is the direct reaction of the suddenly disturbed ego to the element of terror and the physical discomfort associated with the injury

Psychotherapy is the treatment for traumatic neurosis Prophylaxis is often helpful An aviator after a crash in which he is injured slightly or not at all, immediately takes off again, as good prophylaxis against the later development of a neurosis A similar practice helps tremendously in industry, but is harmfully overdone in countless instances Writers agree that compensation claims should be settled promptly, equably and amicably Litigation, appeals and prolonged legal controversies commonly produce "litigation symptoms" which are neurotic manifestations

The Psychoneurotic Back —In a discussion of psychoneurotic backache, Courtney concluded (1) that the backaches of the nervously adynamic, spring not from ideas, but from pathogenic factors of a physical order, (2) that these pathogenic factors have a definite place in the category of disease mechanisms in general, (3) that the most scientific and logical method of combating the pernicious effects of these factors is through agents and agencies which tend to improve the physical structure and stabilize the functional activities of the neuroglandular mechanism of organic life

Railway Spine —Railway spine is a term that is used instead of traumatic neurosis Traumatic hysteria, traumatic neurasthenia are similar labels for those cases in which indirect trauma to the spine results in widely diffused pain and tenderness

Railway spine may be associated with severe local lesions of the spinal column itself Compression fracture of the body of a vertebra is a more common lesion than is generally realized and may result from relatively mild violence Bates makes a plea for roentgen-ray examination of the spine in every patient sustaining a fracture of the os calcis by a fall from a height Under these circumstances routine roentgenographic examination frequently discloses compression fracture of one or more vertebrae even in the absence of any prominent vertebral symptoms Compression of a vertebral body may be so mild that it cannot be detected even in excellent roentgenograms taken shortly after the accident, hence persistence of localized symptoms for two months or longer should lead to another roentgen-ray examination when secondary changes in the vertebra prove the diagnosis Roentgenograms made just before a delayed hearing in compensation cases often disclose evidence of a compression fracture which justifies the claimant's complaints

A relatively mild trauma of the spine may result in widespread pain and tenderness

The exciting cause of railway spine is any form of indirect violence which results in a jar, twist or sprain of part of the spinal column At

A study of the innervation of certain deep somatic structures by Weddell, Sinclair and Feindel reveals that this innervation differs both in pattern and intensity from that of the skin. These findings explain the differences in the subjective and objective results of painful stimulation of the skin and of deeper lying structures.

PATHOGENESIS OF ARTICULAR PAIN

The nature of the stimuli that excite the endings of pain fibers is not fully understood. Lennander has shown experimentally that pinching, tearing, cauterizing, cutting, sticking or the use of faradic or direct electric currents all give rise to the same type of pain when sensitive tissues about joints are stimulated. Lewis has confirmed these observations and has also consistently initiated pain by injection of chemical irritants. With a knowledge that pain can be induced by these different types of stimuli, Williams believes that most abnormalities of joints and peri-articular tissues are accompanied by pain felt in or near the affected joints.

The nature of the stimuli differs in various types of disorders. Postural abnormalities and traumatic joint lesions produce pain by stretching, pinching or tearing supportive tissues. Neoplastic disease, by reason of growth of the tumor and by resultant destructive changes, may interrupt continuity or stretch, pinch or otherwise irritate pain nerves and their endings. Inflammation may excite pain by chemical irritation, stretching, tension, pinching and, if destructive changes of supporting tissues result, by pressure irritation of nerve endings normally protected. Local tissue edema or hydrops of joints can mechanically irritate and produce pain.

Minor injuries of an intervertebral disk and the ligaments about the vertebrae may cause abnormal calcification of these structures. Calcification of the ligaments of a vertebral joint may begin as early as twenty-five or thirty years and give rise to symptoms of pain in the trunk or the extremities.

Acute or chronic adhesive leptomeningitis may cause pain by traction on the dorsal roots to which they are closely applied. The adhesive process may be circumscribed and simulate a cord tumor or it may be disseminated. The nerve may be injured directly or suffer impairment of its vascular supply.

CLINICAL EVALUATION OF PAINFUL SENSATION

The most important aid in the analysis of pain in an extremity is an adequate history. Williams warns that the physical examination cannot compensate for inadequate reconstruction of the onset and the development of the painful sensation. Sir Thomas Lewis emphasized the following characteristics in the history of painful sensation: severity, quality, localization, duration or time-intensity curve of pain, circumstances in which pain develops and duplication of pain.

BREAKING SENSORY NERVE CHANNELS

The effect of anesthetizing peripheral nerves, nerve plexuses, bursae and joints is helpful in accurately localizing the pain site and in determining whether the pain is of central or peripheral origin (Williams).

Wiberg believes that pain in the back may arise in an intervertebral disk, or more specifically in its ligamentous coverings Every surgeon has observed at least one person who has had acute lumbago for a few hours, or a few days Then he suffers from true sciatic pain which is found at operation to be due to a prolapse of an intervertebral disk Wiberg postulates that the ruptured disk which is found in a state of prolapse, shifts forward to the ligamentous coverings and presses on nerve-containing tissues This causes severe pain producing an attack of lumbago When the disk shifts still further, and reaches the nerve root, the person has sciatic pain Burns and Young believe that back pain is due to pressure on the nerves in the ligaments

Effective Stimuli for the Production of Pain Sensation in Various Tissues

Tissue	*Stimulus (approximating the amount which produces tissue damage)*
Skin	*Mechanical*—pin prick, pinch, crush *Thermal*—excessive heat or cold *Chemical*—acid, etc *Electrical*
Muscle	*Mechanical*—firm, massive pressure sprain *Ischemia*—cramp, spasm, anoxia *Chemical*—hypertonic saline
Fasica and Tendon	*Mechanical*—pressure, sprain, strain *Chemical*—hypertonic saline, calcium deposit
Ligament	*Mechanical*—strain, sprain *Chemical*—hypertonic saline, calcium deposit
Joint	*Mechanical*—massive effusion (stretch) *Chemical*—gout
Bone	*Periosteum*—stretch, infection, tumor, osteoid osteoma
Viscus	*Stretch*
Nerve trunk	*Mechanical*—pinch, stretch, tumor *Electrical* *Chemical*

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PAIN SENSIBILITY IN DEEP SOMATIC STRUCTURES

Lewis believed that the skin and the deeper somatic tissues are supplied by two separate systems of pain nerves Descriptive charts of pain distribution have been presented by Kellgren showing the segmental areas of pain outlined by injection of interspinous ligaments These do not correspond exactly with the distribution of dermatomes as demonstrated by Foerster, or the localization of skin tenderness reported by Head This variation suggests that the distribution of these areas of deep pain and tenderness may correspond with the distribution of segmental innervation of the deep structures Kellgren found that pain arising from subcutaneous periosteum was confined to the neighborhood of the point stimulated whereas pain arising from deeply situated periosteum was felt more diffusely

that the pain actually resides in those areas. Barr analyzes the situation as follows:

The impulses which are interpreted as painful are conducted by specialized unmyelinated, fine nerve fibers which have unencapsulated "free nerve endings" in the skin, deep somatic, and visceral structures. They are quite distinct from the nerves concerned with touch and temperature. The neurons concerned with conduction of pain, in common with other sensory neurons, have their cell nuclei in the dorsal root ganglia. Each sensory nerve root has a specific pattern of distribution to the skin and to the muscles, tendons, ligaments, joints, and viscera. Noxious stimuli applied to any of these structures will produce painful sensations. Pain sense is a protective mechanism, and its threshold is at the approximate level of threatened tissue damage. A painful stimulus applied to the skin is accurately and easily localized, but pain impulses arising in deeper somatic structures are poorly localized, poorly differentiated, and the sensation is often projected in uninvolved skin areas supplied by the same nerve root. An accurate knowledge of the somatic and visceral distribution of each nerve root is invaluable in the diagnostic search for the origin of painful stimuli.

Barr reflects that low-back and sciatic pain is a complex subject. Many musculoskeletal structures, endowed with limited functional capacities, must meet the stress and strains of physical activities. There is a large and complex neural component anatomically in close approximation to vulnerable skeletal structures. The combination of low-back and sciatic pain suggests the presence of a combination of associated "causative" factors. There may be local pain due to excessive stress on local somatic structures. Sciatica may be due to associated root pressure. When radiating pain is the dominant symptom, direct root or nerve involvement is usually present. The theory of reflex reference of pain need not be invoked as frequently today as its was before everyone was aware of disk lesions.

The pathological processes involved vary. Each patient interprets, augments or diminishes, and reacts to the painful impulses initiated by them in his own individual fashion.

The major sensory components of the sciatic nerve arise from the first sacral and the fourth and fifth lumbar roots. They supply pain, touch and temperature fibers to their respective skin areas (dermatomes) in a definite pattern. They supply fibers concerned with pain, position sense, and deep pressure to a large group of muscles and their tendons. They also send branches to the capsules and supporting ligaments of the small joints of the foot, the ankle, the knee, and the sacro-iliac joint. They also supply *via* the recurrent nervus sinuvertebralis the posterior joints and the annulus fibrosus of the lower lumbar intervertebral disks, and the adjacent intervertebral ligaments. Barr finds it of interest that these three nerve roots furnish few or no "pain fibers" to the abdominal and pelvic viscera.

Direct stimulation of the nerve endings in somatic or visceral structures is only one of the pain-exciting mechanisms. Noxious stimuli applied to a nerve trunk produce a sensation of severe pain, not well localized, referred usually to areas distal to the lesion but often extending proximally also. Pressure on the sciatic nerve—for example, sitting on a narrow board—

Barr recalls that anatomical investigations have demonstrated that the dural sac enveloping the cauda equina is inelastic and relatively fixed The lower lumbar nerve roots as they emerge from the theca are covered by a prolongation of the dural sheath and have little mobility in the intraspinal portion of their course When the knee is extended and the thigh is flexed (straight-leg-raising test), the lumbosacral roots, particularly the first sacral are drawn distally and are put under tension This firmly fixes the root ventrally against the adjacent disk and allows no opportunity of its escaping pressure from a posterior disk protrusion Articular facet changes due to injury, infection, or degenerative processes may also affect the adjacent nerve root

Spondylolisthesis and spondylolysis may produce root pressure and radiating pain through several distinct mechanisms (*a*) Direct pressure on the posterior surface of the root may occur in the region of the defective articular facet, (*b*) a concomitant disk protrusion may cause root pressure on its anterior aspect (*c*) the roots in some cases of spondylolisthesis may be stretched in their long axes

THE MECHANICAL ORIGIN OF PAIN—MECHANOGENESIS

Even the more frequently encountered lateral disk protrusions with low-back pain and unilateral sciatic pain produce recurring backache for a long time before the onset of true sciatic pain Love believes that this is due to stretching of the posterior longitudinal ligament without compression of the roots of the sciatic nerve When the fragmented cartilage breaks through the posterior longitudinal ligament and actually comes into contact with the nerve root the production of pain is the same as occurs in the presence of neoplastic compression A protruded intervertebral disk can compress and irritate the nerve root without actual rupture of the posterior longitudinal ligament As a result of compression by fragments of a disk, the nerve root becomes edematous and enlarged, and ultimately adheres to the posterior longitudinal ligament and the protruded disk The extradural vessels become engorged and contribute further to compression and irritation of the root Removal of a protruded intervertebral disk with relief of low-back pain and sciatic pain has been performed on more than one patient who previously had been operated upon elsewhere because of an erroneous diagnosis of angioma of the root or spinal cord because of this extradural congestion A true angioma of the spinal cord is very rare yet extradural congestion and enlargement of vessels associated with a protruded intervertebral disk are common

After the stage of nerve root compression and irritation the ligamentum flavum becomes thickened and fibrotic This thickened ligament, lying as it does posterior to the nerve root and filling the space between the adjacent laminae further encroaches upon the spinal canal and compresses the enlarged hyperirritable nerve root

Barr calls attention to the fact that the conscious human being is in a large measure occupied by the pursuit of pleasure or the avoidance of pain

Low-back and sciatic pain is felt by the patient in certain anatomical portions of the back and lower extremities The patient usually assumes

Barr states that at the cortico-thalamic level, all the sensory impulses including those carried by "pain fibers" are received, integrated, and interpreted. Here one invades the fields of psychology and psychiatry and substitutes for anatomical neurophysiology and pathological terminology, such concepts as types of consciousness, perception of sensation, and their repression or augmentation. Fear, anxiety, and preoccupation are potent in augmenting pain. Good physician-patient relationship allays fear and so decreases pain. The inept physician can multiply fears and may contribute to the production of an ineradicable psychic overlay. The psychosomatic problems of low-back pain are fascinating but poorly understood.

Neurosis, such as hysteria, and depression may translate loss of economic security into a powerful augmentation of the pain from a relatively trivial muscle strain.

The Relief of Uncontrollable Pain

For intractable pain, as from carcinoma, subarachnoid alcohol injection is recommended. The alcohol has a lower specific gravity than the spinal fluid and floats to the surface. If the patient lies in the 45-degree angle plane, only the dorsal sensory columns are affected. In some cases of intractable pain, relief can be obtained only by chordotomy, rhizotomy or transection of the spinal cord. Reaction to spinal anesthesia is a good criterion of what to expect from chordotomy.

Therapeutic Partial Transection of Cord.—Before resorting to chordotomy or rhizotomy one should try cisternal puncture and injections of novocaine.

In a discussion of the control of intractable pain in the lumbar region, pelvis and lower extremities, Peet mentioned rhizotomy, chordotomy and transection. He remarked that Dana was the first to propose division of the posterior roots for relief of severe neuritic pain.

Rhizotomy.—Rhizotomy, meaning the cutting of the nerve roots, is performed in cases of multiple sclerosis, intractable pain and spastic paralysis. In 1908 Foerster recommended rhizotomy for the relief of gastric crises. Fay performed cervical rhizotomy to relieve pain in carcinoma of the neck. A suction apparatus will keep the field free from spinal fluid while the posterior roots are being tied. Careful closure of the dura by a continuous silk suture, well soaked in petrolatum, prevents the possibility of a cerebrospinal leak. Tying rather than cutting the roots minimizes the bleeding. Elsberg and Frazier's experiences were not favorable. One objection is the complete anesthesia that inevitably accompanies the complete analgesia.

Chordotomy.—Chordotomy was first suggested by Spiller in 1912. The first chordotomy consisting of division of the pain and temperature fibers, had been performed by Martin in 1911.

Chordotomy, or cutting of parts of the spinal cord, was also proposed by Foerster. Sachs referred to it as the Spiller-Frazier operation. Indications for this operation are chiefly intractable pain and spasticity. Chordotomy is occasionally suggested in cases of extreme pain in the sacral region and the lower extremities. Chordotomy abolishes the pain sense without destruction of the temperature sense. Oldberg recommended it in some cases of torticollis and spastic paralysis. Following Putnam, Oldberg and

produces tingling, numbness, and pain referred down the extremity in a diffuse fashion

In a search for possible causes of sciatica, vulnerable areas in the lower extremity Barr carefully checks for nerve pressure—such as the metatarsal phalangeal joints of the foot (plantar digital neuroma), the region of the



Fig 208 —The major sensory components of the sciatic nerve arise from the first sacral and the 4th and 5th lumbar roots They supply pain touch and temperature fibers to their respective skin areas (dermatomes) (Barr courtesy of Jour Bone Joint Surg)

medial malleolus, the neck of the fibula (osteochondroma), the popliteal space (bursa or cyst), and the sacrosciatic notch Proximal to this point clinical examination of the nerve trunk and roots becomes impossible except for a short segment palpable on rectal or vaginal examination In the pelvis, the lumbosacral plexus passes close to the anterior aspect of the sacro iliac joint and may be irritated by an exudative or inflammatory process

THE ORIGIN AND MECHANOGENESIS OF PAIN IN THE BACK, NECK, TORSO, AND EXTREMITIES

The chief contributors to our understanding of this problem are Lewis, Kellgren, Leriche, Jung, Steindler, Keegan, Luschka, Schlesinger, Friberg, Hirsch, and Barr.

Kellgren described two distinct qualities of pain, one arising from the skin and the other from the deep tissues.

Muscular, ligamentous or periosteal pain is more diffuse than skin pain. The quality of deep pain is dependent upon its diffusion. Skin pain is described as burning and deep pain, as aching. It is preferable to use the terms cutaneous and deep because they can be discussed with reference to a common sensory experience, such as the skin pinch and the muscle squeeze, thus avoiding confusion.

Pain responses may travel up nerve fibers which have different conduction-rates.

Kellgren distinguishes between pain produced by pressure, stretching, movement and leverage. There is regional pain. There is sympathetic pain. There are primary and secondary pains. Etiologically, the important factors are neurogenic, myogenic, circulatory and functional. Functional factors include psychogenic states, malingering, exaggeration and hysteria.

Anatomic pain embraces osseous, periosteal and synovial discomfort. Bone pain is worse at night.

Tenderness to pressure is usually due to infection, swelling of tissue, hematoma, tearing as in cases of injury to a tissue such as a sprain, or a rupture, fracture or a dislocation. Sensitiveness to motion is usually due to irritation of a synovial membrane as in synovitis or in trauma with rupture, strain, sprain, fracture or dislocation. Swelling is usually due to an exudate, as in synovitis.

Limitation of movement may be due to pain, to swelling which mechanically interferes with motion, to changes within a joint which prevent motion or to inability of the muscles surrounding a joint to function sufficiently to produce normal motion.

The *psychiatric basis of pain* is such a large subject that the reader is referred to special publications on the subject. The *metabolic basis of pain* is not well understood. The *nature and causation of pain in the skin of the extremities* is not clear.

Myalgias may arise from causes that produce a low basal metabolic rate. Creatinuria is present in some of these cases (Travell).

DIFFERENTIATION OF ORIGIN OF PAIN IN FRONT AS WELL AS IN THE BACK

Rule of Thumb.—One should remember that if a person complains of pain both anteriorly and posteriorly the following rule will help. If the pain is at the same level front and back, the probable *origin* is *in front*. If the anterior-radiation pain is coming from the spine, the lesion must be at a much higher level in the back than in the front.

Chandler recommended it in certain cases of spastic paralysis It is likewise advised in cases of metastatic tumors of the sacral, lumbar or thoracic vertebræ, for tumors in the pelvis, abdomen or thorax and the condition known as "phantom limbs"

The operation involves removal of the laminæ of two or three vertebræ with exposure of the spinal cord and section of the anterolateral tract The dentate ligament is grasped and the side of the cord is rotated upward so as to expose the tract The section is accomplished by means of a small, sharp knife or by pulling out the fibers with a small hook and then cutting them

The spinothalamic tract which carries the pain and temperature sensation of the contralateral side of the body is located in the anterolateral columns of the cord Spiller recommended that this tract be severed in cases of intractable pain due to pelvic cancer Peet, Kahn and Allan performed bilateral cervical chordotomy for the relief of pain in chronic infectious arthritis

A small laminectomy should be done and a chordotomy performed at least four cord segments above the highest segment of pain distribution With bilateral section of the pain-conducting pathways, between the dentate ligaments and the anterior roots, there will be a loss of pain and temperature sensibility below the level of the section, but touch, pressure position and vibratory sensibilities will not be impaired The knife should pass completely through the white matter, between the landmarks named and well into the gray matter of the cord With a careful operation avoidance of hemorrhage around or in the cord and proper closure of the dura mater and muscles there should be no loss of sphincter control or any motor weakness In such a case chordotomy is no doubt preferable to posterior rhizotomy

THE SYMPATHETIC NERVOUS SYSTEM IN RELATION TO BACK DISORDERS

The sympathetic or autonomic nervous system is a connecting link between the spinal cord and the internal organs peripheral blood vessels and erector muscles of the hair and sweat glands The connection is accomplished by means of the rami communicantes

For the anatomy and physiology of the sympathetic nervous system, the reader is referred to standard textbooks

The importance of the system to the orthopedic surgeon is found in such conditions as spastic paralysis Hirschsprung's disease (celiac disease), arthritis *neuro-circulatory* lesions *neuro-muscular lesions thrombophlebitis* and epiphyseal arrest The subject has been given a tremendous impetus by the works of Royle and Hunter Kanavel Pollock and Davis Adson White Allen Scott and Morton Robertson and others

Surgical measures have been applied to the sympathetic nerves in the treatment of Raynaud's disease thromboangiitis obliterans generalized scleroderma Hirschsprung's disease chronic constipation spastic paraplegia and chronic arthritis

The technics of operative approach are well described by such writers as Jonesco, Royle and Hunter Adson Kanavel *Pollock* and Davis

PSYCHOSOMATIC ASPECTS OF BACK DISORDERS

Psychosomatic medicine represents an orientation in medical philosophy and practice, a perspective that attempts to evaluate the relation of personality factors and life situations to disease or illness. Psychosomatic diagnosis thus, according to Hart depends on a discipline that requires, in addition to a knowledge of the manifestations of disease, a further understanding of its nature and its significance to the patient in terms of personality security. In many diseases, personality factors operate to permit a utilization of the illness for secondary gain, with resultant protraction of symptoms and disability. Various psychologic manifestations arise from specific patterns of reaction to personality conflicts and insecurity.

Patients with psychosomatic disease may show little or no evidence of emotional instability. A calm and sometimes phlegmatic temperament is often abruptly lost if insecurity becomes excessive or if the walls of resistance built up around a person's illnesses, are jeopardized.

The various factors involved are: insecurity, conflicts, resistances, attitudes, behavior characteristics, psychologic expression, physical symptoms of primary psychosomatic disease, conditioned biologic response, purposefulness of the illness, integration of personality, primary gain.

A favorite expression of these medical "window shoppers" is "Doctors do not understand my case." Another is "There is only one thing wrong with me and if I can just get that cured I will be all right." They consult unorthodox practitioners who employ substandard methods. They take patent remedies and embrace medical fads. They offer vague and incoherent recital of complaints. They display excessive preoccupation with irrelevant detail. They have a habit of garrulousness. They exhibit hypersensitiveness and intolerance to personality study. They may reveal illogical and unwarranted optimism and minimizing of serious insecurities. "I can't imagine what is making me so ill", "I've told you absolutely everything I know", "I wish I knew more about myself to tell you."

They may offer misleading explanations such as "Doctor, if you can just find something the matter, I will be all right. I have been to so many doctors and they cannot seem to discover the trouble or understand my case."

ORGANIC vs PSYCHOSOMATIC BACK DISORDERS

There is no doubt that the back is a common location for psychosomatic disturbances. However, I am certain that the organic precedes and supercedes the psychosomatic in the great majority of cases in civilian practice. There is no section of the body to which psychosomatic impulses are directed more often and directly than the back. This includes conscious and unconscious reactions.

Dangers of the Psychosomatic Approach.—Great harm and serious delays may follow unreasonable emphasis on the psychosomatic factor.

Backache is the favorite retreat for exaggerators, malingerers, and slackers. It is one of the most popular avenues of escape from reality. The psychology of the person with a chronic back disorder must be understood in order to evaluate and correct his disorders.

BACK PAIN OF UNDETERMINED ORIGIN

Although the frequency of this situation is decreasing, there are still occasional cases in this category. Conservatism should be the watchword. Watchful expectancy should be the rule.

If one can rule out a serious lesion he can cautiously try ethyl chloride spray. This is effective in attacks of fibrositis, myositis, and bursitis. Injections of procaine are often curative. In the chronic recalcitrant cases neurectomy may be required.

Extra spondylar Causes of Pain in the Back.—Extra-spondylar disorders may affect the back or may come into the differential diagnosis picture. The disorders may be reciprocal, *i.e.*, outside disorders may cause back pain and back trouble may cause distant pain. The chief disorders and regions that may be involved are as follows:

Relation of Disorders of the Hip and Thigh to the Back.—The disorders concerned are chiefly poliomyelitis, contractures, fractures and meralgia paresthetica.

Ober has relieved a few patients who suffered from meralgia hyperesthetica, (lateral femoral cutaneous neuropathy) by tensor femoris fasciotomy. In one case where fasciotomy had relieved sciatic pain, a subsequent fasciotomy relieved meralgia paresthetica.

Relations of Disorders of the Leg, Foot, and Ankle to the Back.—The disorders concerned are chiefly: poliomyelitis, (residual effects), spastic paralysis, contractures, fractures, tumors and circulatory disturbances.

BACKACHES IN ASSOCIATION WITH NEUROSES

Hysteria Compensation

Three causes of the great increase in traumatic neurosis were: (1) World War I. (2) Workmen's Compensation Laws. (3) World War II.

In the treatment one must destroy the value of the person's actions. In hysteria the person is not aware of his dishonesty; the malingerer is aware of it. Every person has a precipitation point and that includes the examiner.

THE NEUROTIC vs. THE NEURITIC BACK

"More people are sick because they are unhappy than unhappy because they are sick." (Swaim)

I have seen many neurotic patients who had neuritic lesions involving the back.

Beware of the neurotic person with backache.

I was dumbfounded for an instant, when one of my neurological colleagues made a remark *about a highly emotional patient whom I had referred to* him because of a cervical disk syndrome:

"Phil, don't take his pain away from him."

The psychological and organic manifestations may grade into each other through an indefinite corridor or they may parallel each other.

The Psychosomatic Back.—Special tests include: 1. Squatting test, 2. Bench or chair test (Burns). 3. Snuff test. Neglect of a complete physical examination may be disastrous.

Patients who can not be expected to perform the test include

1 Those so weakened by injury or disease that they are physically unable to comply with the request

2 Those so diseased at hip or knee that they could not be expected to accept the required strain, weight and leverage at these joints

Patients who may be expected to do the test include

(1) Those with real sciatica The test imposes no strain or pain on the sciatic nerve

(2) Those with congenital anomalies, i e —sacralization of lumbar five or spondylolisthesis

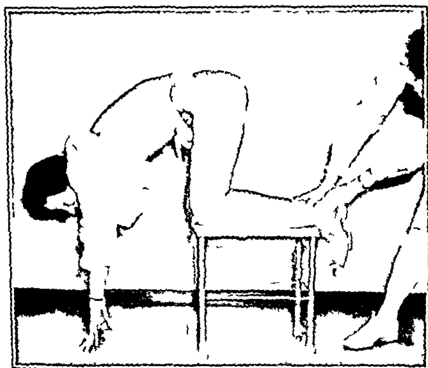


Fig 299 —The kneeling bench test of Burns helpful in detecting malingering

(3) Those with arthritis

(4) Those with specific disease of the spine—tuberculosis

(5) Those with compression fractures of the spine

What is the reaction of the malingerer to the request to perform the test?

(1) He looks at the examiner with an appealing gaze and without making any effort toward compliance says "No Doc I can t do that", or

(2) He bends forward 45° to 60° from the perpendicular, at which time he has subjected his back to all the weight leverage and strain possible, then he rises to the perpendicular and says "No I can't do that" He has already done it The test is complete

RADICULITIS—RADICULAR NEUROPATHY

Radiculitis is an irritation of the spinal nerve roots manifested by pain and alterations of sensation or muscle function The syndrome consists of

If the psychological elements are not corrected, no amount of organic, mechanical or even surgical treatment will effect a cure. Temporary improvement may occur but that is not sufficient. There is no doubt that there is a type of back which I have labelled the "Fatigue Back." There is also an "Exhaustion Back."

The great danger is overlooking an organic lesion. I put the *psychosomaticist* on the defensive, rather than the *patient*. I have seen patients with tuberculosis of the spine, with roentgenologically demonstrable abscesses, who were accused of having a psychological disorder.

Luck studied psychosomatic problems in the military services very thoroughly during World War II and made many valuable observations. There is a big difference between *Battle Fatigue* and *Battle Jitters*. The boy with battle fatigue needs rest, warmth, warm food, a hot bath, a change of clothing, Benzedrine Sulfate. The boy with battle jitters needs assurance and barbiturates.

Fear.—There are many persons who are afraid that "something" *will* happen and others that "something" *will not* happen.

The chief factors involved are: Hate, resentment, guilt, inferiority, fear, anxiety and worry. Fear builds up more and more, the more it is held back, producing a vicious cycle.

Symptoms are like shadows. Many patients go on year after year "shadow boxing." They know they will get better. One must find the cause and bring it out into the open. The patient must be taught how to accept them or dispel them. It may be possible to remove the cause.

Detection of Malingerers.—I treated a steeplechase jockey who was brought to the hospital completely paralyzed after being thrown from a horse during a race.

1. The urethral catheter annoyed him. If he were a true paraplegic he wouldn't feel its presence.
2. He turned over on the Stryker frame during sleep, without help.

When I told his wife he was paralyzed, she took it in stride and said he had had several attacks. Every time he was thrown from a horse he became "paralyzed."

An analysis of the psychosomatic analysis should reveal: (1) The incentive to *do* certain things and (2) The incentive to *avoid* or to *refuse* to do certain things.

THE BURNS' BENCH TEST

The Kneeling Bench—Test for Malinger in Backache.—Pain, tenderness, muscle spasm and restriction of motion may all be feigned by the patient. Burns' test is a negative test and is unique among the tests for backache. It has been used routinely since 1940. Any individual may perform the test, whether he does or does not have backache, providing he has integrity of hip and knee and providing he is not so debilitated that weakness precludes the possibility of his performing the test.

A surgical bench 18″ high with a pad of Belgian foam rubber to cover it, is all the equipment required. The patient is instructed to kneel as far forward as possible on the bench. The examiner grasps the back of the patient's ankles meanwhile asking the patient to bend over and touch the floor with his finger tips.

The symptoms depend on the vertebral level involved Cervical involvement is associated with headache, sore neck, painful shoulders and arms Upper thoracic involvement is associated with precordial pain which is often considered to be of cardiac origin Pain in the epigastrium and over the region of the gall bladder is noted when the mid thoracic vertebrae are involved Pain over the lower part of the abdomen, which requires a differential diagnosis from appendicitis and pelvic disease, is associated with involvement of the lower thoracic vertebrae Involvement of the lumbar vertebrae is associated with painful hips and thighs as in disease of the hip joint and in so-called meralgia paraesthetica, or with pain over the back and lower extremities, as in sciatica

Sneezing affects the upper spinal roots more than straining at stool, which involves the lower spinal roots The acts that constitute Dejerine's sign cause an increase in intraspinal pressure and probably act mechanically on the roots and their meningeal coverings Metrazol treatment aggravates radicular pain

Root pain is referred to the cutaneous areas supplied by the affected nerve roots (dermatomes) If numerous roots are involved the pain is widely distributed A characteristic of root pain is its intensification by coughing, sneezing, heavy lifting or straining, as in defecation All these acts have in common a sudden increase in intra-abdominal, intrathoracic or intraspinal pressures The nerve roots may even be compressed by the distended veins surrounding them

The term "sciatica" refers to a pain which extends from the sacroiliac region into the posterior or posterolateral part of the thigh and calf It is most commonly caused by a lesion involving the nerve roots in the spinal canal This produces the radicular syndrome

Lesions of nerve roots cause more than 95 per cent of all cases of sciatica, and more than 90 per cent of these radicular lesions are protruded intervertebral disks

A partial list of the common causes of radicular pain was given by Williams

Herpes zoster	Tumors of spinal cord
Meningitis	Tumors of dorsal roots
Tabes dorsalis	Metastatic vertebral carcinoma
Arthritis	Syphilis
Hypertrophied ligamentum flavum	Syringomyelia
Fracture	Hematomyelia
Dislocation	Myelitis
Disk protrusion	

The most common of these is a protruded intervertebral disk Ninety-five per cent of all lumbar and upper sacral nerve root lesions are attributable to protruded intervertebral disks

Two components of pain prerequisite according to Millikan are con- stant aching, burning discomfort with stiffness low in the back and down along the course of the sciatic nerve It must go to the knee increasing severity of the pain

restricted mobility of the spine, root pain and root sensory alterations produced or aggravated by movement Radiculitis may be manifested in any portion of the body including the arms, the trunk, the thorax and the lower limbs Osteo-arthritis of the spine may be the cause of pain and sensory disturbances of spinal root distribution, either from the meningeal reaction secondary to the osteo-arthritic process or from pressure in narrowed canals

Parker and Adson concluded that the process is inflammatory with infection and trauma as the prominent factors Pressure on the nerve due to an exudate may occur in the intervertebral foramen or in the region of the

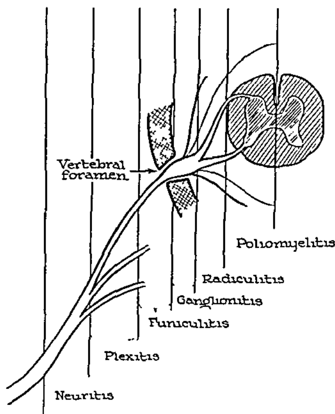


FIG 300 —Diagrammatic representation of various sections of the central nervous system from the spinal cord to a peripheral nerve When irritation or inflammation occur in specific sections different signs and symptoms occur and different diagnoses are made (Redrawn from *Putti Lewin s Infantile Paralysis courtesy of W B Saunders Company*)

articular facets Diminution in the size of the foramen causes pressure on the nerve root which is reflected along the course of the nerve producing pain

The history includes repeated attacks of pain stiff neck or lumbago painful shoulder, sciatica pain in the back chest or abdomen The cardinal symptoms are pain, *aching and soreness induced or aggravated by movement* of the vertebræ associated most commonly with sneezing straining at stool and coughing rising from a sitting position raising the head on awakening getting out of bed walking, sitting in one place for any length of time, change of position and lifting Pain at night may be a striking feature

relief on getting up and walking about or to avoid or to alleviate the pain by sitting up in a chair to sleep The intensification of root pain at night frequently has been attributed to nocturnal increase in intraspinal pressure A more likely factor seems to be related to the known fact that the spinal column is elongated when one lies down

Pain resulting from disease of the sensory nerve roots secondary to extramedullary tumors of the spinal cord, protruded intervertebral disks and other spinal lesions, occurs in the distribution of the nerve root involved

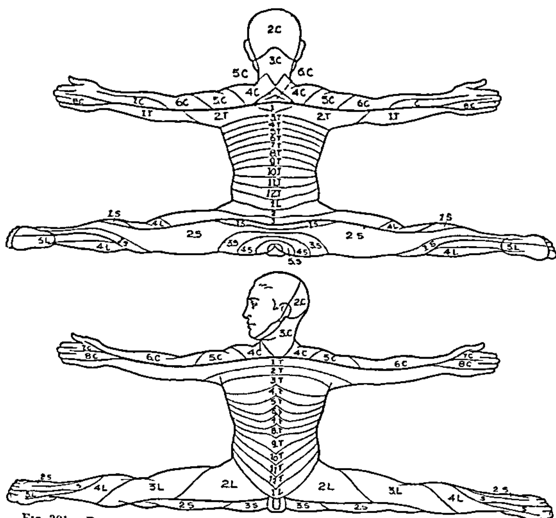


Fig 301 —Diagram showing segmental distribution of spinal nerves (Webb-Johnson)

and frequently is localized in a small part of the total region supplied by that nerve root Sensory alterations to light touch and hyperalgesia or hypalgesia to pinching can be demonstrated

Treatment —Treatment includes rest in bed on a hard mattress, head traction pelvic traction, physical therapy eradication of foci of infection dietary regulation, medication including B_1 injections into the nerves and or around other tissues, and in some cases surgical measures

Peripheral neuritis and neuropathy may be due to infection, injury, metabolic disturbances changes of temperature and moisture or to chemicals The pathological changes are swelling due to edema hemorrhage and

This is the reverse of the findings in fibrositis or myositis

If the examiner suddenly flexes the patient s head forward onto his chest without telling him what one is doing or why, he may complain of pain Then one asks what happened and he says he has pain Then one asks "Where was the pain?" If he places that pain low in the back or says that the pain did travel along the course of the sciatic nerve it is extremely valuable evidence

Organic disease almost always is present If the stretch across the meninges produces pain on the other side it is almost an infallible sign of nerve root irritation

Young found that protruded intervertebral disks cause more than 90 per cent of all lumbar radicular syndromes

Important abnormal physical signs of the radical syndrome are

1 Stiffness in the lower part of the back
2 Specific weakness or atrophy in the leg
3 Subjective or objective impairment of sensation in the lower lumbar dermatomes
4 Specific diminution or absence of the achilles tendon reflex and,
5 Painful or limited straight leg-raising test

Badgley discusses "The Posterior Syndrome which is characterized by irritation of the sensory nerves in the soft tissues of the neck or pelvis posteriorly which produces radiation of pain along the pathway of the sciatic nerve

The anatomical locations of sciatica may be (1) In the sciatic nerve (2) in the lumbosacral plexus or (3) in the component nerve roots of the sciatic nerve

Sciatica is attributable to nerve root lesions in about 90 per cent of cases Symptoms are constant aching and burning shooting pain of increasing severity extending at least to the knee and low back pain

Indicators of root pressure include aggravation by coughing sneezing, straining or defecation motor disturbances sensory changes, reflex changes jugular compression lumbar puncture myelography nucleography

Other manifestations are local tenderness sensory changes motor weakness, *reflex changes atrophy Naffziger test Lasegue test* spinal puncture findings roentgenographic changes

Another characteristic of root pain is the production or intensification of pain by any maneuver which stretches the nerve root This is often of particular value in distinguishing pains of extraspinal origin Eaton calls attention to the difficulty of telling whether a given pain in the distribution of the sciatic nerve is due to sacro-iliac arthritis or to an intraspinal lesion such as protrusion of an intervertebral disk If bending the neck so that the chin rests far forward on the thorax while the lower part of the back is immobilized by support in a chair definitely intensifies the pain one should suspect that the origin of the pain is intraspinal Stooping forward without bending the knees straight leg raising and extending the knee when the hip is flexed on the abdomen are maneuvers which tense the roots of the cauda equina and produce pain in roots that are involved Another characteristic of root pain is its onset at night during sleep and its subsequent

7 Variable roentgen-ray findings, frequently with evidences of marked arthritis and other hypertrophic changes of the vertebra

8 At laminectomy, varying degrees of swelling of caudal roots, sometimes with adhesions between the roots and the arachnoid

THE FILUM TERMINALE SYNDROME

(The Cord Traction Syndrome)

Garceau reported his observations on patients presenting symptoms of a progressive spastic paralysis Harmeier and Tarlov believe that the filum terminale contains all the histological tissues of the spinal cord

Kleinberg reported a case of paraplegia occurring in a patient with a congenital scoliosis

Garceau's patients developed progressive spastic palsy while under observation for other conditions The first had a congenital scoliosis, the second had recovered from tuberculosis of the spine, the third had idiopathic scoliosis

The cord traction symptoms associated with dysraphism have been recognized for many years The syndrome has been associated with simple spina bifida occulta meningocele myelomeningocele hematomyelia congenital scoliosis, Klippel-Feil syndrome, cranium bifidum, tight fibrous bands and bony spicules All of these conditions may be associated with congenital deformities especially in the lower extremities These deformities are usually evident at birth The neurological abnormalities may be progressive

In Garceau's first patient, the tight filum terminale had prevented the distal migration of the spinal column so that the conus medullaris had retained the foetal position Paralysis occurred during the period of rapid growth

The tight filum terminale may cause spinal cord compression over an angulated spine It may also cause cord traction, pulling the hind brain into the foramen magnum

In all 3 of Garceau's patients the filum terminale appeared to have been the cause of progressive paralysis of the lower extremities The paralysis appeared and progressed during the period of rapid growth In none of his patients did he find an extensive defective development of the dural sac A sacral cord was present in one patient All made remarkable recovery or improvement following sectioning of the filum terminale

The Arnold Chiari Syndrome is usually associated with deformities of the spine and spinal cord

The onset of the paralysis is usually between the age of thirteen and nineteen years Garceau believes that a tight filum terminale may cause the symptoms of traction on the spinal cord known as the Arnold Chiari Syndrome

McKenzie and Dewar concluded that in 21 of 24 patients operated upon for scoliosis with paraplegia the cause of the paralysis was a tight dura stretching over an angulated spine

round cell infiltration in the dorsal intervertebral sensory ganglions and in the gray matter of the spinal cord The symptoms are local and referred pain, tenderness to touch and sensitiveness to movement Circulatory changes are common Muscular weakness may be marked, and paralysis may occur The differential diagnosis includes local and general infections, arthritis, acute rheumatic fever, chronic rheumatism, circulatory and skin disturbances, muscle and tendon inflammation, bursitis and poliomyelitis The treatment includes *protection of the member, search for the etiological factors and their removal*, physical therapy and splinting The peripheral neuritis found in beri-beri is due to vitamin B deficiency

Synthetic Vitamin E Therapy —Blakeslee used vitamin E therapy for 3 patients with peripheral neuritis associated with the Guillain Barre syndrome, 1 with characteristic signs and symptoms of congenital amyotonia and 1 with the differential diagnosis between amyotrophic lateral sclerosis and muscular dystrophy of the Aran-Duchenne type Each of the 5 patients showed definite improvement following the therapy

NEURONITIS

Moersch uses the term *neuronitis* when the process involves the entire neuron Neuronitis (radiculoneuritis, polyneuronitis) usually has a history of a preceding infection Partial motor paralysis appears early, involving the distal muscles especially of the lower limbs Accompanying or even preceding the weakness there is a sensory disturbance, peripheral in type and variable in degree The deep reflexes are diminished or abolished Sphincter function is usually intact The affected muscles are tender The condition is slowly progressive Facial muscles may be involved Convalescence may be long

THE SYNDROME OF CAUDA EQUINA RADICULITIS

According to Cramer, diagnosis of the syndrome of radiculitis of the cauda equina is based upon the following

1 A history of pain in the lower part of the back, often radiating down the lower limbs and frequently sudden in onset, followed by a steady progression of symptoms and signs, with a tendency toward spontaneous remissions

2 Increasing diminution of power in the lower limbs, with foot-drop diminution or loss of the patellar and especially of the Achilles reflexes with preservation of the abdominal reflexes

3 Diminution or loss of sensation over the lumbar, and especially the sacral dermatomes

4 Diminution or loss of control of the vesical and rectal sphincters

5 Absence of spinal arachnoid block in most instances, occasionally a partial or even a complete block

6 Cerebrospinal fluid, generally clear and colorless, though xanthochromic in a few instances, no increase of cells, in some cases globulin and total protein within normal limits, in others globulin increased and total protein between 50 and 80 mg or more

ing, tingling and pain which are aggravated by standing or walking. Usually there can be found slight loss of appreciation of light touch, pain and thermal sensation in the affected area. It may be associated with a disk lesion.

It can be relieved by simple severance or resection of the nerve. Injection of the nerve is indicated and in some cases section of the nerve at its exit from the pelvis without excision, the nerve ends being left in alignment so that spontaneous regeneration and subsequent nerve lengthening may take place. Stookey recommended diagnostic and therapeutic procainization of the nerve before section.

In a personal communication from Dr. Byron Stookey, he said: "Meralgia paresthetica is characterized by an area of dysesthesia to anesthesia in an area of skin, exquisitely limited to the distribution of the external lateral cutaneous nerve. This area is distinct and entirely different from any radicular or dermatomic area. It is an area supplied by a peripheral nerve and can be produced only by irritation of a peripheral nerve. Were it produced by an irritation of a disk, the area would then be radicular and dermatomic in distribution.

Of course, a patient with meralgia paresthetica may have a disk or pain in the back, but if so, the symptoms would be entirely different, and not limited to a peripheral nerve area."

The question of the role of the tight filum terminale as a cause of idiopathic scoliosis remains unanswered. Garceau is now attempting to produce scoliosis in monkeys by preventing the migration of the spinal column away from the conus medullaris.

MERALGIA PARÆSTHETICA

(Lateral Femoral Cutaneous Neuropathy)

This condition is manifested by numbness on the anterior and especially on the outer surface of one thigh, which becomes painful only after prolonged exertion or by pressure.

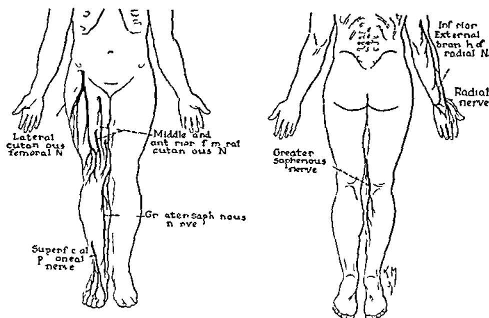


Fig. 302.—Sensory nerves in which a mononeuritis has been described. (Ecker and Waltman, courtesy of Jour. Am. Med. Assn.)

Meralgia paræsthetica was described by Stookey as characterized by burning, tingling, numbness, cold or severe pain in the area of distribution of the external cutaneous or cutaneous femoris lateralis nerve which arises in the 2d lumbar segment. The area involved is the anterolateral region of the thigh. Stookey expressed the belief that meralgia paræsthetica, or preferably neuritis of the external cutaneous nerve, is a true traumatic involvement of the nerve as it leaves the pelvis, where it is predisposed to repeated injury.

Rosenheck's study of 25 cases of meralgia paræsthetica revealed this lesion as due to irritation or compression of the nerve in the intervertebral spaces or foramina due to an osteo-arthritic process.

Neuritis of the lateral femoral cutaneous nerve is caused usually by pressure or tension of the overlying fascia. It usually begins as a sense of numbness over the anterolateral aspect of one thigh, although both thighs may be affected. Later, to the numbness are added the sensations of burn-

Neuro-arthropathies follow peripheral nerve injuries with greater frequency than is generally believed. They are often misinterpreted on account of the absence of demonstrable disease of the central nervous system. The possibility of neuro-arthropathy should always be considered when there are obscure or ill-defined joint manifestations, even in the absence of spinal cord disease.

Charcot believed that the joint changes in the disease which bears his name resulted from a destruction of trophic nerve fibers in the spinal cord. Phillips and Rosenheck stated that the joint lesion was a result of peripheral nerve degeneration, which they were able to demonstrate microscopically in a number of cases.

The association of bony changes—limited principally to joint structures—with serious disease of the central nervous system, has been observed for a great number of years. The occurrence of such structural osseous anomalies in the course of tabes dorsalis and syringomyelia was given impetus by Charcot, who was the first to describe them accurately. Thus the term, Charcot joint, was interpreted as a destructive arthritic process dependent on and secondary to, a disease process of certain fiber tracts in the spinal cord parenchyma.

Wile and Butler found that the greatest incidence of Charcot's arthropathy is between the ages of thirty-five and fifty-five. The onset is gradual and insidious, extending over months or years. The occasional, apparently sudden development is frequently the result of trauma which brings to light an existing subclinical process. Charcot's arthropathy occurs three times more frequently in men than in women. Polyarticular involvement is common, no joint being immune, but knee, ankle and back are affected far more commonly than any other members. Cerebrospinal syphilis is present in the majority of cases. Its absence, however, when the involvement is typical, indicates that syphilis is not the essential primary etiological factor. Where it is present, the form of involvement is commonly tabes dorsalis. The treatment must be continued over a long period.

The number of multiple spinal arthropathies is striking. The lesion may extend over several vertebrae. In 7 of their 8 cases Garvey and Glass found positive evidence of destruction of more than one intervertebral articulation. The roentgenological appearance is one of destruction accompanied by proliferation. The vertebral bodies present extensive dissolution, loss of contour and diminution in size. Intervertebral spaces are absent, and degenerated tissue products are in abundance.

Neuropathic arthropathies are found with tabes dorsalis, syringomyelia, compression and destruction of the spinal cord, severance of nerves, pernicious anemia and peripheral neuropathy. In tabes dorsalis the joints of the lower extremity are usually affected.

Charcot joint is due to neurotrophic and infectious factors. Because of the neurotrophic factor, normal trophic impulses fail to reach the joint. The infectious factor is an active local agent or its toxic by-products.

King expressed the belief that hypertrophic Charcot disease is a form of osteoarthritis and that aggravation of the process is due chiefly to the more frequent traumatisms permitted by the hypesthesia of the bone and joint structures. While a neurogenic background predisposes a joint to

CHAPTER 42

THE SPINAL ARTHROPATHIES

SPINAL arthropathies include a group of pathological joint lesions caused by impairment of sensory nerve function and characterized by swelling hypermobility, poor stability, and an unusual freedom from pain or tenderness

The neurological and the traumatic arthropathies are most interesting

Traumatic Arthropathy—Traumatic arthropathy of the back may follow a fall, a twist or a blow The symptoms are pain and disability The physical sign is tenderness on pressure Serious disability may be due to stiffness, with pain in the vertebral joints on movement, This follows the swelling incident to trauma of the back The treatment is symptomatic and is described under strains and sprains

Spinal arthropathies, according to Ridlon and Berkheiser, are observed most frequently in the lumbar region They occur usually in men, the average age of occurrence being about forty-four years The average period between initial infection and appearance of the arthropathy is eighteen years The onset is insidious, but may be precipitated by trauma

The pathological changes in the bones are destruction proliferation and displacement New bone deposits are abundant and in Garvey and Glass's cases were attached to the spine, as contrasted with the loose bone plaques frequently seen in the knee ankle and hip Bone changes in the spine frequently appear before ataxic symptoms develop, but they may appear coincident with or subsequent to the recognition of the ataxia Arthropathic changes may be present in other joints

The pain, paresthesias and paralysis which appear in the lower extremities in some cases seem to be due to the mechanical effect of pressure on the nerves at their exits from the spinal canal

A rapidly developing painless deformity of the spine should always excite suspicion of a Charcot arthropathy and lead to further search for symptoms that may substantiate the diagnosis

From examination of the roentgenograms two types of pathological changes appear in these joints *the osteosclerotic or consolidation type,* and the osteoporotic or rarefaction type

Ridlon and Berkheiser advise using a plaster leather or celluloid jacket made over a corrected plaster torso All patients should be given sufficient antisyphilitic treatment to maintain a negative Wassermann reaction of the spinal fluid

Neuro-arthropathies—World War I with its rich array of neurological material and peripheral nerve injuries proved that the so-called Charcot s joint, or the neuro-arthropathy could exist independently of disease of the central nervous system

even though they are the first symptoms of oncoming tabes, and (2) immediate and adequate protection of the joint to prevent detrimental external influences. Protection against these influences by early and adequate splinting, preservation and protecting of the musculature by physical therapy, above all, early stabilization and alignment by conservative or operative means, furnish the best prospect of preserving the usefulness of the joint.

Pain in the back may be relieved by stretching the spine, correcting the deformity as far as possible and supporting it in a well-fitting corset. Temporary stretching or other movements at the region of bone changes may give temporary relief to the less important nerve symptoms or mechanical impingements of the spinal nerves supplying the legs, but more serious complications as foot drop, find no permanent relief, on account of the injury to the nerves.

CHARCOT'S NEUROPATHIC LESION INVOLVING THE SPINE

Although the name of Jean Martin Charcot is attached to this clinical entity, it was Mitchell in 1831 who, according to Stack, first described the 'Charcot Joint'. In 1868 Charcot presented his classical paper concerning the relationship of lesions of the brain and spinal cord with the existence of arthropathy. He supported the theory of the trophic origin while Volkmann and Virchow, believed in the purely mechanical theory.

Etiology.—Steindler in 1931 summarized the etiological factors. The high points were Mitchell's work in 1831 which associated spinal cord lesions and certain joint diseases. Charcot in 1868 added tabes dorsalis to the list; myelitis was added in 1875, poliomyelitis in 1873, and syringomyelia in a neurotrophic joint following a shrapnel wound, another following a knife wound of the back which resulted in hemiparalysis, and a case due to hematomyelia.

The two main causative factors appear to be tabes dorsalis and syringomyelia. About 6 per cent of individuals who have a proven case of tabes will show some joint involvement. Anywhere from 10 to 40 per cent of patients with syringomyelia develop Charcot joints.

The causative factors are probably a combination of the theories of Charcot and the school of Volkmann. Basically there must be a lesion in the central or peripheral nervous system to produce a relatively anesthetic joint, which when subjected to the trauma of life will show outstanding and typical signs of degeneration.

Floesser in 1917 made an outstanding study of the pathogenesis of the neurotrophic joint. He attempted to show that trauma, whether single and substantial or multiple and trivial to an anesthetic joint, was the basic factor in the development of neurotrophic changes.

Freund considered the neurotrophic joint to be an extreme form of degenerative arthritis. When the knee is involved and extreme degrees of medial and lateral instability and recurvatum are present, serious disability is the rule.

Neuropathic arthropathies are found in tabes dorsalis, syringomyelia, compression and destruction of the spinal cord, severance of spinal nerves

arthropathic disintegration, mechanical and traumatic events determine the course of the disease and lead to the breakdown of the articulation

Charcot joint is painless in most cases, and may develop rapidly, producing joint instability

The lesion has been produced experimentally in animals by section of the posterior (sensory) roots which inhibits the warning sense of pain in a limb Charcot joint may be the result of a single trauma, like that of a fracture into a joint Its recognition is, therefore, important in the adjustment of industrial and military claims and in determining liability Compensation should not be denied the patient with inactive syphilis in whom a Charcot joint appears immediately after a severe injury received in pursuance of his occupation or in the military services

Pathological Changes —The pathological changes are extensive destruction of articular cartilage and bone The ligaments and capsules undergo stretching and weakening There is bone destruction with loosening of bone plaques Bone proliferation may progress simultaneously with the destruction

Symptoms —The pupils do not react to light (Argyll-Robertson) Tendon reflexes are occasionally exaggerated at first but absent later There may be "lightning' pains especially in the legs The Romberg sign shows instability while standing with the eyes closed There are such motor disturbances as an ataxic gait, involuntary movements and palsies Gastric crises and disturbances of the visual, auditory and visceral apparatus may be present

Sensory disturbances *i e* analgesia 'tabetic cuirass" hyperalgesia and delayed transmission of sensation are noted Wassermann and Kahn tests of the blood and spinal fluid should be made The spinal fluid examination consists of cytological, chemical, the Lange colloidal gold and other tests The therapeutic test of antisyphilitic treatment is helpful Local signs are swelling and absence of sensitiveness

Roentgen ray Findings – The most characteristic roentgen finding is extensive destruction of bones, but in the hypertrophic type there is also proliferation of bone Loose bodies are common Atrophy is absent because the joint is not painful and is therefore used The roentgenogram reveals simultaneous destruction of the articular surfaces and of the bones, with an irregular hyperplasia of bone in the surrounding tissues The destruction revealed by the roentgenogram is entirely out of proportion to the clinical findings

Diagnosis —It is necessary to differentiate Charcot joint tuberculosis, arthritis, synovitis osteomyelitis aseptic necrosis of bone, fracture, dislocation, malignancy and septic infection

Treatment —The treatment is stabilization and when indicated, antisyphilitic medication Stabilization consists of the application of braces or plaster-of-Paris casts or fusion Removal of the remaining cartilage and debris joint resection and immobilization have resulted in benefit in a number of cases Antisyphilitic medication consists of arsenicals bismuth, penicillin, mercury and iodides

Steindler emphasized the following (1) the earliest possible detection of the arthropathic joints by roentgen examination in the pre-ataxic stage,

Steindler believes that while a neurogenic background predisposes a joint to arthropathic disintegration, mechanical and traumatic events are the factors that determine the course of the disease and lead to the breakdown of the joint

Heyman believes that a Charcot joint may be the direct result of a single trauma such as a fracture into the joint The recognition of this factor is important in the adjustment of claims in industrial cases and in determining the employer's liability Compensation should not be denied the patient with inactive syphilis or neurologic condition, who develops a Charcot joint which appears immediately following an undoubtedly severe injury received in the pursuance of his occupation

Charcot believed that the disease was conditioned or preceded by a trophic change in the joint The two arguments advanced for this are first, that there occurs a subchondral condensation of bone, and second, some patients develop full blown arthropathies with little demonstrable neurologic disease The more widely held theory was originated by Volkmann, who believed that loss of deep sensibility was followed by repeated injuries in other words, one is dealing with an anesthetic joint which allows multiple injuries without the person being cognizant of the trauma or taking precaution to avoid trouble This leads to neglect of treatment

Key states that tabetics in whom the lower cord symptoms are marked are more liable to develop Charcot joint than those in whom the symptoms are referrable to the upper cord

Pathology —The pathologic changes in the back include extensive destruction of bone articular cartilage The ligaments and capsule undergo stretching and weakening There is bone destruction with loosening of fragments

Signs and Symptoms —A Charcot spine is characterized by instability with progressive destruction of bone but usually without pain The pupils do not react to light (Argyll Robertson) Tendon reflexes are occasionally exaggerated at first, but absent later There are 'lightning' pains, especially in the legs The Romberg sign consists of instability in standing while the eyes are closed There are motor disturbances such as an ataxic gait involuntary movements and palsies Gastric crises and disturbances of the visual auditory and visceral apparatus are present

Sensory disturbances *i e* analgesia tabetic cuirass, hyperalgesia and delayed transmission of sensation are observed Wassermann and Kahn tests of the blood and spinal fluid should be made Spinal fluid examination consists of cytologic chemical and the Lange colloidal gold and other colloidal tests The therapeutic test of anti-syphilitic treatment is helpful

Tabetic joints may occur at any stage in the development of the disease although they seem to be more common in the pre-ataxic stage In syringomyelia Charcot's joints develop rapidly during a late stage

Roentgen ray Findings —The roentgenogram may reveal with the loss of joints margins bony sclerosis and destructive arthritis Bone proliferation is seen in the hypertrophic type may progress simultaneously with the destruction The most characteristic finding is extensive destruction of bone Proliferation of bone occurs in the hypertrophic type Atrophy is noticeably absent owing to the fact that this type of joint is not painful,

pernicious anemia and peripheral neuritis Tabes dorsalis is prone to affect the joints of the lower extremity whereas syringomyelia usually involves those of the upper extremity

Charcot's knee is an unstable enlarged joint which may be painful only at the onset Serologic and neurologic studies confirm the diagnosis of syphilis, syringomyelia or other neuropathic disorder



FIG 303 — A case of proved syphilitic Charcot disease of the spine involving all the lumbar vertebræ

The two factors involved are the neurotrophic and the infectious elements The neurotrophic factor consists of the absence of normal trophic impulses reaching the joint The infectious element means the presence of a local infective agent or concentration of its by-products in the joint

King believes that hypertrophic Charcot's disease is a form of osteoarthritis The aggravation of the processes is due to the more frequent minor or major injuries which are permitted by reason of the hypesthetic condition of the bone and joint structures

CHAPTER 43

SCIATICA—NEURITIS—NEUROPATHY

POLYNEURITIS means multiple nerve involvement caused by such conditions as virus infection, absorption of bacterial toxins, alcohol, lead arsenic or phosphorus, and avitaminosis, especially vitamin B_1 deficiency

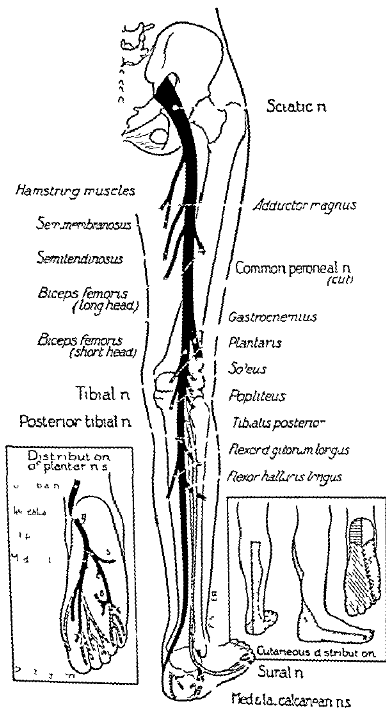


FIG 304 —Haymaker and Woodhall (Courtesy W B Saunders Co)

and therefore, is used Sutherland found that the roentgenogram reveals a simultaneous, enormous destruction of the articular surfaces and of the bones with an irregular hyperplasia of bone in the surrounding tissues The destruction, as seen in the roentgenogram, is entirely out of proportion to the clinical findings

In about a third of the cases, roentgen examination is made early enough to reveal changes consistent with ordinary but severe hypertrophic arthritis In this case, spur formation and lessened joint space are present

Diagnosis —The differential diagnosis lies between tuberculosis, arthritis, synovitis, osteomyelitis osteochondritis, aseptic necrosis of bone, fracture dislocation malignancy and septic infection

In Key s series of cases there was none in which the diagnosis of neurosyphilis could not be made from the physical and laboratory examinations The most prominent symptoms suggesting neurosyphilis were shooting pains in the extremities, ataxia, bladder dysfunction visceral crises optic atrophy, disturbances of sensation in the lower extremities and impotency

Treatment —Two factors are important in regard to management of this disease, as described by Sherwood and Hutchins One is the recognition that it is not merely a syphilitic process but rather a condition which results from disease of the spinal cord This explains why a Charcot joint may develop during the successful treatment of tabes It is the result of changes already present in the cord and not a sign of advancement of the spinal lesion The second fundamental of treatment is recognition that the immediate local cause is repeated trauma to the bones and joints

Usually the patient will get along surprisingly well until the instability reaches a point at which it is necessary for him to wear a brace to prevent collapse of bone

Treatment may be conservative in the form of some type of external fixation apparatus The choice is largely indicated by the neurologic and general condition of the patient If his condition is such that he may be ambulatory and useful operation is the method of choice If the prognosis of the tabes is poor brace treatment is to be favored

Steindler emphasizes the following (1) The earliest detection of the arthropathic joint by roentgen examination in the pre-ataxic stage even as the first symptoms of oncoming tabes (2) Immediate and adequate protection to prevent harmful external influences

In the treatment of tabetic arthropathies it is important to treat the underlying neurosyphilis in an aggressive and intelligent manner and to treat the ataxia by muscle re-education

Many forms of treatment have been advocated—casts for immobilization and stability, braces for stability

Key notes that about one third of the patients who have developed a neurotrophic joint will at some time again develop another The advantages of a solid fusion for such an unstable back are many and obvious providing that a reasonable degree of success can be anticipated There are conflicting reports concerning the ability of these bones to fuse following proper surgical preparation

ANATOMY

Anatomy —Since a large number of patients suffering from sciatic pain have lesions involving the nerve roots which compose the cauda equina an accurate knowledge of the anatomical aspects of this structure is essential The spinal cord usually terminates opposite the intervertebral disk below the 1st lumbar vertebra The nerve roots forming the cauda equina arise from the lumbar and sacral regions of the spinal cord descend in the subarachnoid space intradurally and are freely movable except as they

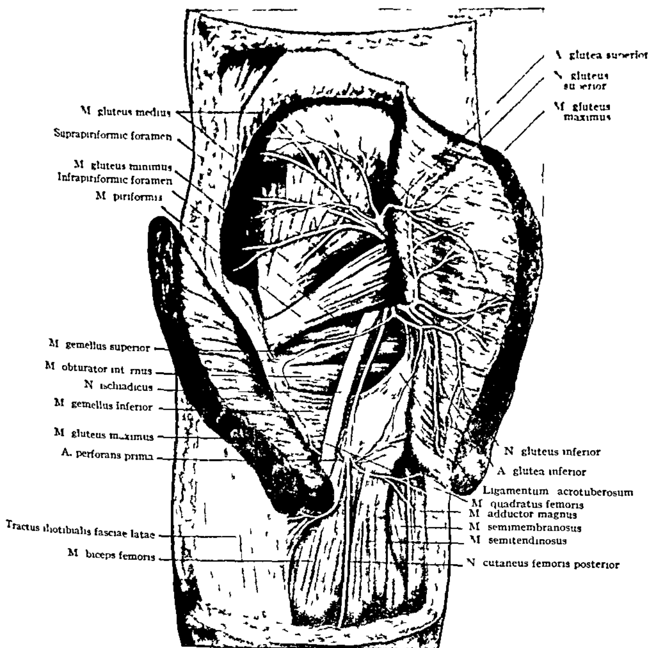


Fig 307 —Deep structures of the gluteal region A large segment of the gluteus medius muscle has been removed to expose the gluteus minimus Attention is called to the piriformis muscle as the key landmark of the deep structures All of the important gluteal vessels and nerves emerge through the suprapiriformic and infrapiriformic spaces (Callander's Surgical Anatomy courtesy of W B Saunders Company)

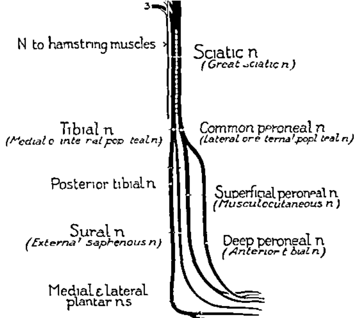


Fig 305 —Diagram of the Division and Branches of the Sciatic Nerve The nerve to the hamstring muscles is incorporated in the sciatic trunk The tibial nerve becomes the posterior tibial at the upper border of the soleus muscle (indicated by broken lines) Synonyms for the various nerves are included (Haymaker and Woodhall courtesy of W B Saunders Co)

Fig 306 —The various branches of the lumbar plexus (Touhy courtesy of W F Prior Company)

approach their exits where they are fixed. Intraspinal lesions can displace and impinge on nerve roots without causing any motor, sensory or reflex changes, and can produce pain. Protruded intervertebral disks and hypertrophied ligaments can produce pressure on nerve roots without producing any symptom except pain.

The term neuritis will be limited to painful involvement of peripheral neurones caused by such pathological changes as infiltration, pressure or inflammation which produce disturbances in conductivity, motor power and sensation. In neuralgia there is no pathological change in the nerve which can produce changes in conductivity, motor power or sensation.

The sciatic nerve, the largest and longest nerve in the body, is the continuation of the flattened band of the sacral plexus. It originates in the

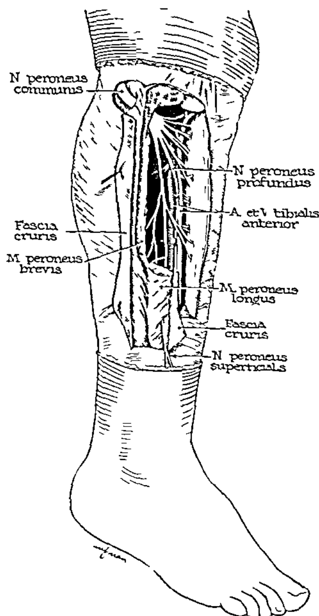


Fig. 310.—Dissection of leg to show relations of external popliteal component of the sciatic nerve

Long head of biceps femoris

Semitendinosus
Semimembranosus

Sciatic branches to external hamstrings

Sciatic branch to internal hamstrings

Short head of biceps femoris

Adductor magnus

Sciatic nerve

FIG 308 —The course of the sciatic nerve in the thigh (Redrawn from Campbell s Operative Orthopedics courtesy of The C V Mosby Company)

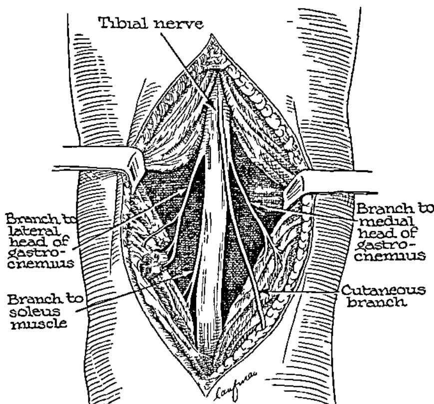


FIG 309 —The course of the tibial component of the sciatic nerve in the leg (Redrawn from Campbell s Operative Orthopedics courtesy of The C V Mosby Company)

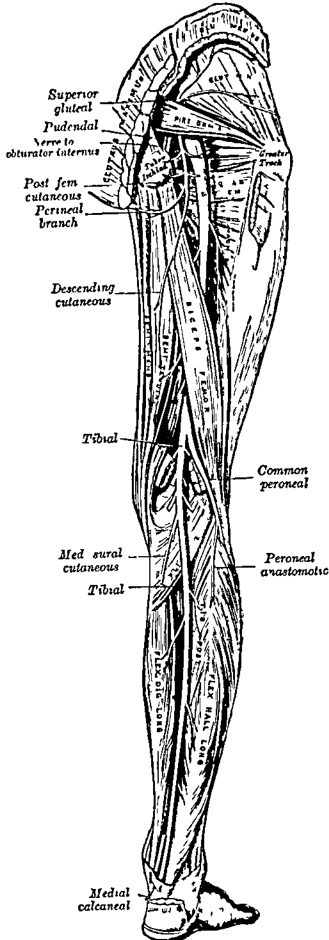


FIG 311 —Nerves of the right lower extremity Posterior view (Gray)

4th and 5th lumbar roots, which are components of the lumbosacral cord, and more especially in the 1st 2d and 3d sacral roots Its roots lie in close relationship to the intervertebral disks between the 4th and 5th lumbar vertebræ and the 5th lumbar and sacrum At the level of the sciatic notch, all its components unite into one band The nerve passes around the ischial spine and descends in the posterior part of the buttock between the ischium and greater trochanter The piriformis muscle bridges the widest portion of the nerve and occasionally is split by the components of the nerve

The nerve descends in the posterior part of the thigh into the interspace bounded by the semimembranosus and the semitendinosus medially and the biceps femoris laterally It rests on the posterior surface of the femur which is covered by the insertions of the adductors and by the vastus externus The nerve becomes superficial at the upper end of the popliteal space, where it divides into its two terminal branches, the tibial and common peroneal nerves In about 15 per cent of subjects, the division occurs as high as the plexus itself, the nerve peronæus running through the muscle piriformis and the nerve tibialis below it

THE SCIATIC SYNDROME

The term, sciatica, accredited to Cotugno, has been applied to any condition characterized by pain in the lower part of the back and the lower limbs, regardless of the cause and clinical manifestations The term has been applied to such *conditions as sciatic neuralgia, sciatic neuritis,* sciatic radiculitis, protruded intervertebral disk, meralgia paræsthetica, lumbago, myalgia and myositis Although the term sciatic awas originated by Cotugno in 1764 it was one hundred years before Lasegue described his diagnostic sign

Descriptions by Lasegue (1864) of the carriage and posture of patients having radiculitis of the sciatic nerve components were remarkably accurate The sensory changes observed by Dejerine (1914) in patients with "sciatique radiculaire are identical in nature, with the changes due to rupture of an intervertebral disk

To Cotugno sciatica became a clinical as well as an anatomical problem Familiar with the older literature particularly the types described by *Hippocrates, Cotugno differentiated from them a true nervous form* in which the lesion is localized in the sciatic nerve itself

Pathological Anatomy —The pathological changes are pressure neuritis and associated changes Arthritis of the lumbar lumbosacral and sacro-iliac regions may involve the articular facets or the intervertebral foramina The intervertebral foramina have been called the cross-roads of neuralgia

Etiological Factors —Pure sciatic neuritis is rare It probably does not occur except as a condition due to arsenic or lead poisoning or to an infection, or as alcoholic or syphilitic neuritis as an avitaminosis or from anemia

Sciatica may be due to diabetes syphilis alcoholism lead poisoning or any lesion producing an inflammatory or degenerative change directly in the nerve tissue Symptomatic sciatica is a local condition which may produce pain *either by direct pressure upon, or irritation of* the sciatic nerve at some point along its course or at its roots

Sciatic Pain and Hyperglycemic Response to Glucose Tolerance Test — Recent interest in the neuritis due to vitamin B deficiency has produced some observations that tend to support the idea that the so called diabetic neuritis is due to the same deficiency

Thirteen cases of sciatic pain are presented by Smith in which there was no obvious etiological condition other than the hyperglycemic response to the one-hour, two-dose glucose tolerance test Eleven of these made complete recovery on a diabetic diet, insulin, and vitamin B_1 therapy

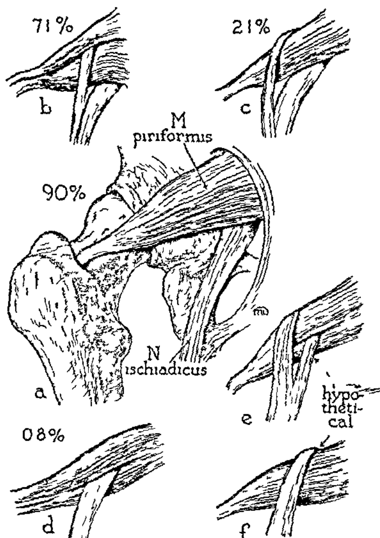


FIG 312 —Six types of arrangement of the sciatic nerve or of its subdivisions in relation to the piriformis muscle arranged in the order of frequency Gluteal (external) view The percentage incidence in 240 examples is indicated Figures *e* and *f* are hypothetical the others are actual cases *a* Nerve undivided passes out of greater ischiadic foramen below piriformis muscle *b* divisions of nerve pass through and below heads of muscle *c* divisions above and below undivided muscle *d* nerve undivided between the heads of muscle *e* divisions of nerve between and above heads (hypothetical) *f* undivided nerve above undivided muscle (hypothetical) (Beaton and Anson courtesy of J Bone and Joint Surg)

ANAL LESIONS AS A CAUSE OF SCIATICA

Carmichael emphasized the fact that anal lesions are connected with the sciatic nerve by both sympathetic and parasympathetic nerve fibers

The predisposing factors in sciatic pain are congenital anomalies, postural defects, and metabolic, circulatory and endocrine disturbances Determining factors are infection, trauma, exposure and fatigue Any focus of infection, or exposure to cold or dampness, especially when one is warm, may precipitate an attack Vitamin deficiency is also a predisposing cause

THE PIRIFORMIS SYNDROME AND ITS RELATION TO SCIATICA

In 1928, Yeoman called attention to the fact that the lumbosacral plexus is separated from the sacro-iliac joint by the piriformis muscle and its fascia of origin In his opinion any lesion of the sacro-iliac joint may cause an inflammatory reaction of the piriformis muscle and its fascia

The piriformis muscle arises "from (1) the lateral part of the ventral surface of the 2d, 3d, and 4th sacral vertebræ, (2) the posterior border of the great sciatic notch, and (3) the deep surface of the sacrotuberous (great sacrosciatic) ligament near the sacrum "

This muscle being in contact with the anterior ligament of the sacro iliac joint and the roots of the 1st, 2d and 3d sacral nerves, its lower border is closely related to the whole trunk of the sciatic nerve It is an abductor and external rotator of the hip and in the act of walking it is also a flexor of the hip It is relaxed in flexion and outward rotation, a position commonly assumed by patients with acute sciatic pain

A large branch of the inferior gluteal artery with its accompanying vein crosses the sciatic trunk under the belly of the piriformis

The relation of the piriformis to the sciatic nerve is especially close, particularly regarding the common peroneal portion There is a possibility of the mechanical effect of pressure on the nerve resulting from continuous spasm of the muscle

The relation of the piriformis muscle to the sciatic nerve and the neuro vascular plexus between them appeared strongly suggestive to Freiberg and Vinke Between the piriformis and the sciatic trunk there is a rich vascular plexus coming from the inferior gluteal vessels The sciatic nerve can be pinched between the piriformis muscle and the iliac bone

When the thigh reaches approximately 25 to 50 degrees of flexion with the trunk, the hand within the pelvis can plainly feel the tightening of the sacrotuberous ligament and the piriformis muscle as well It would seem that this is the most plausible explanation of Lasegue's sign or the straight-leg raising phenomenon which many writers have ascribed to the stretching of the sciatic nerve

Anatomical study shows that the sciatic nerve is not put on the stretch, until the extreme of hip flexion is reached and that most sciatica patients reach the limit long before this One must consider the possible mechanical effect of pressure on the nerve as the result of continuous spasm of the muscle

Gluteal Bursitis —Gillette found that gluteal bursitis could cause sciatic pain Hench and Wakefield reported a case of postural sciatica in association with congenital hemihypertrophy which was relieved by balancing the pelvis Flat-feet may aggravate sciatic pain by superimposing a mechanical static factor

segments, from which the sciatic nerve and its components are derived), by affections of the lumbosacral plexus or by lesions of the sciatic nerve itself

The cardinal symptoms are pain, aching and soreness, induced or aggravated by movement of vertebræ, associated with sneezing straining at stool, coughing rising after sitting or getting out of bed The chief manifestation is pain referred along the course of the sciatic nerve This may appear in the back, gluteal region, hip or down the thigh and leg to the foot The location is determined by the area compressed

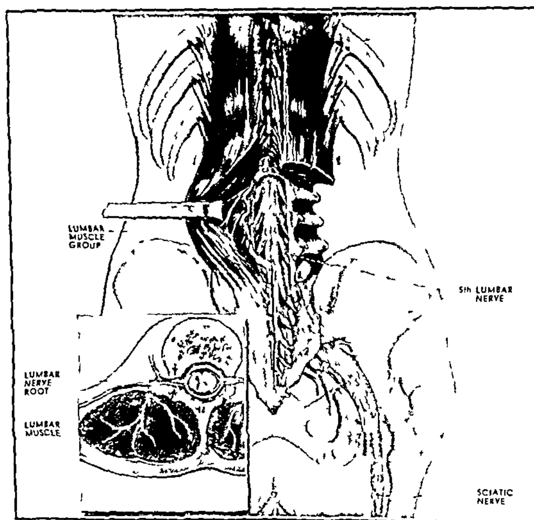


Fig 314 —The primary pathway of low back pain and sciatic pain (Courtesy of The Calco Chemical Company)

Physical Examination —The most frequent points of tenderness described by Freiberg are found at the following sites (1) the supraspinous ligament between the spinous processes (2) the periosteal attachment of the erector spinæ muscles to the dorsum of the sacrum (3) the origins of the gluteus maximus and medius along the iliac tuberosities and crests (4) the piriformis muscle in an area midway between the greater trochanter and the posterior-superior iliac spine, (5) the iliotibial tract or fascia lata

These provide a pathway for excessive nervous impulses which may arise from anal lesions and which are expressed as reflex symptoms Sciatica may be due to either a sympathetic or parasympathetic anal stimulus The site of an anal lesion causing sciatica may be foretold by the vertical zone of hyperalgesia it causes

LUMBOSACRAL DISTURBANCES AND SCIATIC PAIN

Danforth and Wilson studied the anatomy of the lumbosacral region in relation to sciatic pain, from four standpoints anatomical dissections, clinical examination of the spine, neurological examination for localizing evidence, and roentgenological examination They found in their dissections that the foramen between the 5th lumbar vertebra and the sacrum is always the smallest, that between the 4th and 5th vertebrae is the next larger and that between the 3d and 4th is usually the next largest In contrast to the size of the foramen is the size of the nerve root enclosed The 5th is always the largest, the 4th, next to the largest and the 3d next smaller Otherwise expressed, the largest nerve root, the 5th, always has the smallest canal and frequently it almost fills the canal, while the 4th rarely fills the opening and the 2d and 3d never does

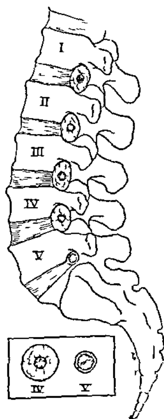


Fig 313 — Diagrammatic representation of the relation between the lumbar nerve roots and their foramina The last foramen is smaller but is traversed by a large nerve when compared with the other lumbar structures (Modified from Danforth and Wilson Jour Bone and Joint Surg)

Symptoms —Sciatic pain occurs chiefly in adult life, more commonly in men, usually those in occupations which necessitate heavy manual effort and exposure There is frequently a history of preceding trauma The pain often begins as 'lumbago' and after a variable period of from a few days to several weeks makes it appearance in the thigh leg or ankle The pain may begin in the leg, and there may be no pain *or only slight pain in the back The pain* may be constant or spasmodic and may be aggravated by movement, coughing and sneezing, or by assuming certain positions Its intensity varies from mild to severe with periods of acute exacerbation The pain usually follows the course of the sciatic nerve to the knee and then is referred to the outer side of the leg and ankle During the period of acute pain and subsequently for a varying period, a spinal deformity is present, the trunk being tilted to one or the other side

Pain is a subjective complaint, something that cannot be seen and cannot be palpated and necessitates cautious interpretation of what the patient relates Pain occurring in the distribution of the sciatic nerve may be caused by a lesion of the spinal cord or nerve roots (especially from the 4th lumbar to the 2d and 3d sacral

as the fabere sign ("fabere" is derived from the words, *f*lexion, *ab*duction, external rotation and extension) With the patient supine the right heel is placed above the left patella and the right knee allowed to touch the table If there is involvement of the hip, the right knee remains "hung up" in the air The test has been called "the sign of four"

A possible tumor of the spinal cord must always be considered, especially when the sciatica is bilateral One is not justified in regarding the Lasègue sign as pathognomonic of involvement of the nerve Rectal and vaginal

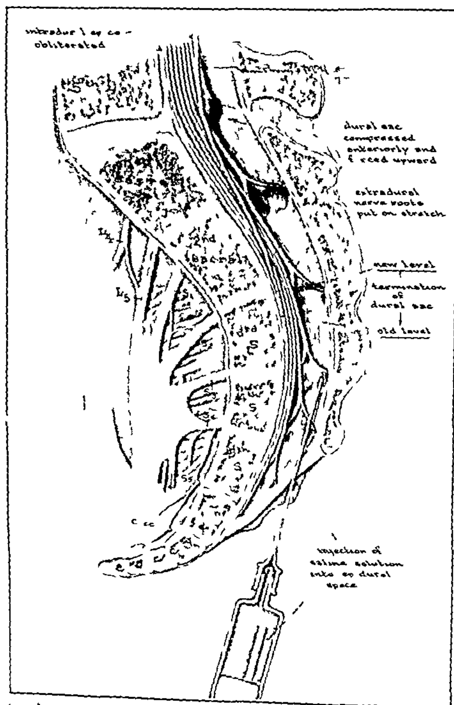


Fig. 1 — Non-operative procedures for the relief of lumbo-sciatica (Steele courtesy of Am Jour Surg)

over the greater trochanter and between the greater trochanter and the iliac crest, (6) the sacro-iliac notch or the posterior-inferior, sacro-iliac ligaments, (7) the lumbar zygapophyseal joints, about 1 inch lateral to the spinous processes

The knee jerk may be diminished or absent Hypesthesia and gluteal atrophy may be present Loss of the Achilles jerk indicates that the process involves the nerve bundles Harris considered this the earliest sign indicating actual damage to the nerve fibers, invariably preceding anesthesia of the foot and muscular wasting, and usually preceding coldness, numbness or blueness of the foot

In sciatic neuralgia and neuritis, muscular hypotonia is evident in the region of the affected nerve, and is of particular importance as it is the only objective sign In certain rebellious neuralgias of long standing, as well as in neuritic or radicular attacks of sciatica, more marked changes of attitude may be observed Often there is a scoliosis with its convexity toward the affected side, this is Brissaud's "crossed sciatic scoliosis"

A patient suspected of having sciatica should have a thorough back, hip and foot examination

Roentgen ray observations are of the greatest importance in the study of the causes of sciatica Positive findings are very important and must be accurately evaluated in order to avoid being misled Negative findings are of great value in eliminating certain lesions from the list of diagnostic possibilities The roentgen examination should include all bones and joints from the 10th thoracic to and including the hips Anteroposterior and lateral films are imperative and oblique and stereo films are often very helpful Roentgenograms of the lumbosacro-iliac regions often reveal congenital anomalies and arthritic or traumatic changes Changes in the sacro-iliac joints may show spur formation indistinct outlines fusion or sclerosis Williams called attention to the fact that in the majority of cases of sciatica there is narrowing or a complete loss of the space between the 5th lumbar vertebra and the sacrum To this he attributed the sciatica, by reason of 'motion at the lumbosacral joint plus the constriction of the intervertebral foramen and the arthritic lipping which follows the loss of joint space As a matter of fact these furnish evidence of a disk derangement

Diagnosis —Diagnosis of the level of the lesion is important for surgical treatment and depends on (1) development of a sensory level (2) motor disturbances, (3) trophic disturbances and (4) sympathetic disturbances

No diagnosis of sciatica is justifiable without a careful pelvic examination Pain in the buttock may be due to superior gluteal neuritis The patient should have a neurological examination, followed by an orthopedic examination

Differential Diagnosis —It appears that at the present time the differential diagnosis is a matter of 'a disk *versus* the field The more mysterious the signs and symptoms the more likely they are due to a disk disturbance The more intense and intractable the pain, the more likely it is due to a protruding disk The differential diagnosis concerns the lesions involving the lumbosacro-iliac region and the region of the hip Patrick emphasized a sign known by his name, as the Laguerre sign and

and routine materials for novocaine injection The patient is placed on his side Watson Jones uses the position of extreme kneeling with the patient sitting on his legs The puncture area is localized at the sacrococcygeal hiatus Through a simple puncture, normal saline solution is injected to insure that the needle is in the sacral canal After the injection of novocaine I routinely apply a pelvic adhesive strapping In some cases of tight leg and pelvic tissues, I manipulate, apply a brace, start physical therapy and prescribe vitamin B_1

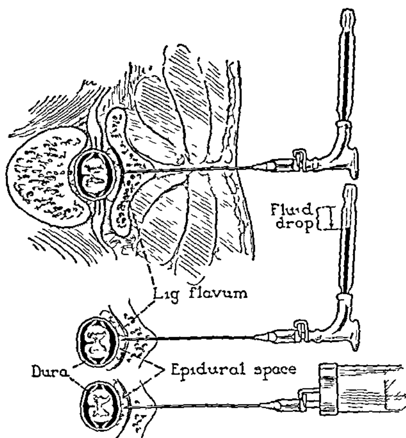


Fig 317 —Technic of peridural anesthesia showing needle introduced through ligamentum flavum into peridural space and demonstrating the negative pressure in this area by means of a fluid dropper in the glass adapter (Touhy courtesy of W F Prior Company)

An epidural injection of 30 to 60 ml of a 1 per cent novocaine solution into the sacral canal produces sacral anesthesia and is often followed by relief from a chronic low backache or sciatica

Vitamin B_1 —From personal experience including several hundred cases I have found semi-weekly subcutaneous injections of 50 to 100 mg of thiamine chloride to be quite effective in office practice In hospital cases I prescribe 100 mg intravenously daily Spies has had very favorable results following the administration of vitamin B fractions

General measures should include adequate rest and attempts to build up the patient's resistance A high-vitamin high-caloric diet large doses of cod liver oil and iron, removal of foci of infection with salicylate medication for pain are the most beneficial measures Transfusions are frequently valuable, even when the anemia is only moderate The use of vaccines,

examinations may be helpful. By the former, one is able to palpate the sciatic nerve and the lower margins of the sacro-iliac joint, and in the male to eliminate pathological changes in the prostate gland and seminal vesicles. In a man past fifty, sciatic pain should immediately call to mind carcinoma of the prostate.

In making a differential diagnosis one must always be on his guard to detect a hypochondriac, a psychoneurotic, an exaggerator or a malingerer.

Prognosis.—The prognosis is always doubtful. The course is often long. Some residual trouble may persist and predispose to subsequent attacks.

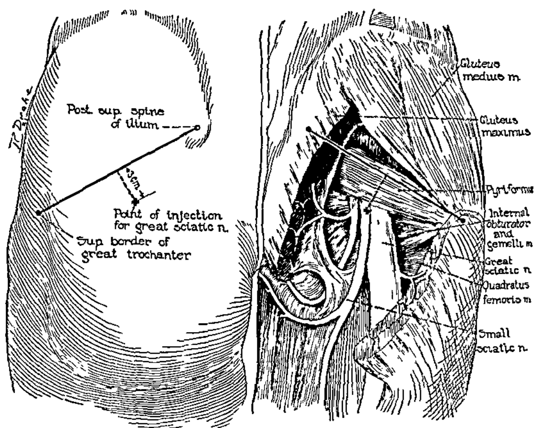


Fig. 316.—Block anesthesia of the greater and lesser sciatic nerves. (From Labat's Regional Anesthesia, courtesy of W. B. Saunders Company.)

Treatment.—The non-operative treatment involves chiefly rest, support and physical therapy. Many patients with mild sciatic pain are relieved by pelvic strapping. Adhesive plaster is applied tightly across the lumbar, sacral and iliac regions both in front and behind. This is followed by the wearing of a pelvic support or brace. A scultetus binder with peroneal straps is helpful, especially for patients who are sensitive to adhesive. Intravenous tolserol is usually very effective.

Caudal Epidural Injection in the Treatment of Sciatic Pain.—The chief object is the relief from pain. It also has some diagnostic value. A previous study of each case including a neurological examination is imperative. The chief contraindication is a sensitivity to novocaine and tuberculosis of the spine. The technic includes the simple armamentarium of a spinal needle

this the patient should be fitted with a spinal brace to be worn during the day. He is instructed to sleep on his back at night. A board should be placed between the mattress and spring. The pillow should be discarded. Many patients obtain relief by lying face downward with their feet protruding over the end of the mattress, which had been pulled several inches toward the head of the bed. Deep breathing exercises should be taken often to prevent the loss of thoracic respiration.

I have treated many patients with lumbar, lumbosacral and sacro-iliac arthritis by manipulation of the lumbar spine and sacro-iliac region, the hips and the hip joint, with uniformly good results. I have also treated many patients by caudal epidural injection, and it occurred to me that combination of the two methods would be highly beneficial. I have carried out this method in several cases and am pleased with the results.

I have found **traction on the leg or pelvis** effective in many cases. Pelvic traction is applied by placing a belt around the lower part of the abdomen and suspending weights from ropes that pass over pulleys and are attached to webbing straps sewed to the back of the belt. For application of traction to the leg, either moleskin adhesive or a resinous plaster on swansdown is used.

When all pain and sensitiveness disappear, one must decide whether a **plaster-of-Paris spica** extending from the costal margin to a point below the knee, should be applied. If this is advisable, one must be careful to protect with felt pads the iliac crests, the patella and the sacrum. When walking is permitted, crutches are used. A 1½- or 2-inch wood or cork lift is attached under the heel and sole of the shoe of the opposite side, so that the foot of the affected side does not touch the ground. After from one to six weeks a "sacro-iliac belt" with a lumbosacro-iliac pad should be worn instead of the cast. When more support than the belt is needed, a special corset with uprights of aluminum or a spinal brace should be worn. Prolonged diathermy may be effective. Massage of the region of the nerve is usually contraindicated, but gentle massage or light superficial stroking may be soothing.

While the foregoing orthopedic treatment is being given, all general, focal, metabolic and other disturbances are investigated and eradicated. Analgesics, sedatives, opiates and vaccines have their places in the treatment. Attention to intestinal stasis, infection and metabolism is imperative in many cases. Dietary regulation with lubricants and colonic irrigations may be used.

Barsé and Gunsett treated 20 patients with vertebral arthritis by roentgen irradiation, claiming that 12 were cured, that 5 were relieved of pain and 3 underwent no change. When pain was the dominant symptom, Pfender advised roentgen therapy as giving the best response by acting on the connective tissue surrounding the nerve in the intervertebral foramen and reducing the inflammatory reaction.

Operative Measures. — There has been considerable discussion concerning operations for relief of sciatic neuritis. Freiberg recommended myotomy of the piriformis under local anesthesia. In some cases he recommended removing a section from the piriformis and the iliotibial band. Indications for his operation are: (1) positive Lasègue sign, (2) tender sciatic notch, (3) relief by traction.

gold salts and hyperthermia have been disappointing. The specific measures are orthopedic. The most important is the prevention of deformities. A stiff spine in good position is not a severe handicap and can be attained in most cases in which the diagnosis is made early. To accomplish

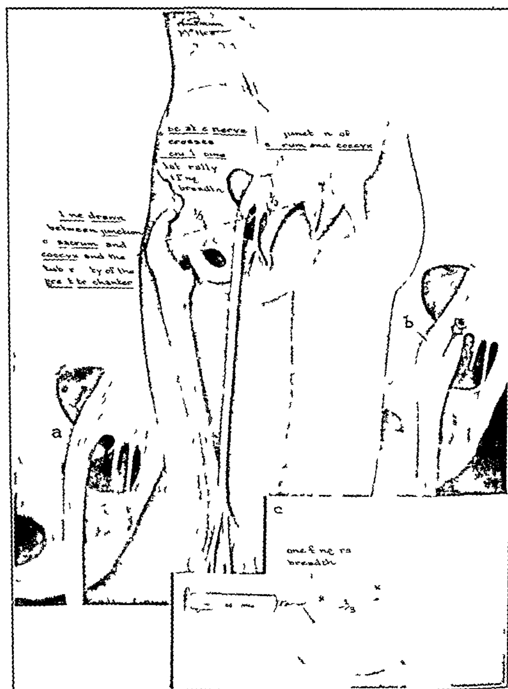


FIG. 318.—Regional anatomy of sciatic nerve in the sacrosciatic notch. The surface landmark is a point one fingerbreadth to the lateral side of the medial third of a line drawn from the sacrococcygeal junction to the lower point of the great tuberosity of the femur. The deep landmark is the spine of the ischium. A, Size and position of the sciatic nerve as it lies on the spine of the ischium. B, Fusiform swelling of the nerve twice normal size following the intraneural injection of 2 cc. of fluid. C, Needle plunged vertically into the soft tissues at the surface landmark. (Steel; courtesy of J. Bone and Joint Surg.)

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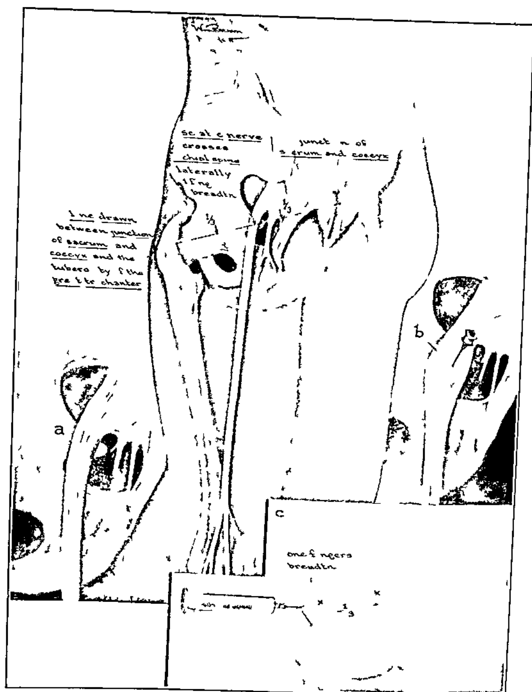


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PARALYSIS OF THE SCIATIC NERVE AND ITS COMPONENTS

The sciatic nerve divides into the tibial and peroneal nerves In about 15 per cent of cadavers this division occurs as high as the lumbosacral plexus itself, when the peroneal nerve runs through the piriformis muscle and the tibial nerve passes below it The muscles supplied by the external popliteal branch suffer greater damage, as a rule, than those supplied by the internal popliteal

With paralysis of the great sciatic nerve, one is unable to (1) balance on the affected side, (2) flex his knee, (3) extend his thigh, (4) raise his foot, (5) rise on his toes, or (6) to "beat time" with the foot of the affected side

With internal popliteal nerve paralysis one is unable to "point his toe," to adduct his foot, to flex or to separate his toes The calf group becomes flabby and the tendo achilles loses its prominence

With external popliteal nerve paralysis, a foot-drop appears and one is unable to raise his foot Signs of recovery from external popliteal nerve paralysis are similar to those described under sciatic paralysis

The order of return of function is the gastrocnemius, tibialis posticus peronei, tibialis anticus, extensor longus digitorum and the flexors of the toes

Tourniquet Paralysis of the Sciatic Nerve —The experimental work of Allen indicates the vulnerability of nerves to the tourniquet Paralysis of the sciatic nerve due to tourniquet pressure is a rare sequel to the use of the tourniquet during operations on the lower extremity Unfortunately it is sometimes permanent, as reported by Bennett It is most likely to occur when a thin thigh is strapped too tightly without a towel protecting the skin Burman found that a narrow tourniquet is less injurious than a broad tourniquet Speigel and Lewin have written on this subject

Maternal Obstetrical Sciatic Paralysis —Kleinberg found that maternal obstetrical sciatic paralysis rarely follows a severe labor in which a decided difference between the size and shape of the pelvis and that of the fetal head is encountered and in which extensive instrumentation has been employed The paralysis is apparently due to an increase in the intrapelvic pressure, causing trauma to the sciatic nerves The symptoms usually appear immediately after the delivery but at times are delayed several days They are bilateral and include motor and sensory changes Foot-drop resulting from involvement of the external peroneal nerve is a conspicuous sign It may disappear partially or completely, but may at times remain permanently The treatment is entirely symptomatic and the prognosis must be guarded

Obstetrical Paralysis of the Peroneal Nerve —According to A Whitman, paralysis of the peroneal nerve from pressure on the main trunk of the sciatic nerve in its intrapelvic portion occurs during prolonged or difficult labor, either from direct pressure or from the presence of a large head in a small pelvis

Obstetrical Paralysis of the Obturator Nerve —I have seen one lesion following an episiotomy I treated a woman who had traumatic obturator neuritis which occurred during delivery Late paralysis of the anterior crural nerve following childbirth has been described by Cary

TRAUMATIC SCIATICA

Traumatic sciatica means sciatic neuritis following injury to a normal back The medico-legal importance of this condition is attested to by the numerous and often just causes for controversy In order to be eligible for this classification, the history symptoms, physical and roentgen-ray findings must permit integration to justify the diagnosis The treatment is rest, support by adhesive strapping, belt, or brace, traction, physical therapy, manipulation and injections

LUMBOCRURAL NEURALGIAS OF COLONIC ORIGIN

Brule and Garban direct attention to the frequency with which patients who have disorders of the large intestine complain of pain in the lumbar region, from the 12th rib to the iliac crest, it is localized especially in the superior third of the buttock, a little outside the sacro iliac symphysis and in the root of the thighs, from the anterior superior iliac spine to the pubic symphysis Walking is painful because of the lumbar rigidity and the sense of heaviness in the lower limbs The most constant of these painful points are the gluteal, femorocutaneous, crural and obturator areas

SCIATIC SCOLIOSIS

In sciatic scoliosis there is pain along the course of the sciatic nerve and a shifting of the entire trunk to one side This condition involves the same causative factors as arthritis or neuritis, congenital anomalies, infections trauma, exposure and metabolic disturbances Men are more often affected than women Osgood emphasized absorption of toxic substances elaborated in the large intestine The relation to protrusion of the intervertebral disks is discussed in a succeeding chapter

The chief symptom is pain along the course of the sciatic nerve The physical signs are shifting of the torso There are usually considerable pain and tenderness which causes the body to shift to one side in order to avoid pressure on a sensitive area The most frequent type of scoliosis is the heterologous form in which the trunk deviates away from the affected side Brissaud used the term 'contralateral" scoliosis as contrasted with homolateral scoliosis In cases of alternating sciatic scoliosis the one image is not the exact mirror image of the other although at first one the appears to be the exact counterpart of the other Capener has proved this point

Roentgenographic examination may reveal congenital anomalies or arthritic changes in the lumbosacro-iliac region The course may be protracted and recurrences are common

Treatment includes such general measures as search for foci of infection and *orthopedic treatment* Rest in bed is advisable with physical therapy, the use of radiant heat, massage and inductothermy Analgesic medication may be helpful especially with the cinchophen or the salicylate group Thirty grains of sodium salicylate in 3 ounces of tap water given by rectum every two or three hours for 6 to 10 doses may be effective The gastrointestinal tract is important especially in overweight persons

show that compression of the nerve itself adds to the ischemic condition and increases the paresthesia, in the cutaneous field of the compressed nerve It is not the mechanical action on the blood vessels but the mechanical effect on the nerve trunk itself that determines the typical ischemic and postischemic paresthesias

Driver's Thigh —Hoets called attention to a condition recognized by motor drivers, which he called "driver's thigh" It is a neuralgia or a neuritis of the sciatic nerve observed in those who spend a large part of their time driving or sitting in a motor car Symptoms vary from an ill-defined feeling of fatigue of the thigh muscles to those of classical sciatica The cause is long-continued pressure on the sciatic nerve just before its point of division in the lower third of the thigh The pressure may be produced by the use of the accelerator pedal, which requires that it be held in one position for long periods The trouble appears only when the person sits badly or the springs of the seat have given way Tilting of the seat backward usually relieves the discomfort

The Treatment of Peripheral Nerve Lesions —The non-operative treatment of peripheral nerve paralysis includes physical therapy, heat massage, passive and active exercise, electricity, and splinting The operative treatment includes neurolysis or liberating a nerve, neuroplasty, meaning any plastic surgery done on a nerve, neurotomy, or making an incision into a nerve, neurectomy, or the division of a nerve, nerve suture suturing the ends or sides of a nerve, nerve transposition, nerve transplantation, or the grafting of a nerve into another nerve or into a muscle

In a divided peripheral nerve, a primary nerve suture should be attempted Contused and crushed portions of the nerve should be removed until normal funiculi herniate from the ends Ney emphasized the prevention of rotation or torsion of the nerve trunk in suture which can be accomplished by several different methods (1) identification suturing, (2) funicular or bundle matching (3) forceps identification, (4) anatomical or striation markings I advise different color sutures or variations in the artery forceps attached to the sutures The epineurium should be completely closed, for if developing neurofibrils stray into the surrounding tissues, a dense scar (neuroma) may form which will seriously interfere with nerve repair and will cause pain

Early use of muscles is desired and for this reason an elastic apparatus is preferable to a rigid splint in maintaining the neutral or slightly overcorrected position

Nerve defects may be overcome according to Ney, by one or a combination of the following methods (1) primary stretching, (2) flexion relaxation (3) transposition, (4) two-stage operation, (5) grafts

Nerve grafting is the last surgical resort for repair of large losses of nerve tissue Delageniere called it the most logical method There are heteroplastic, homoplastic and autoplastic grafts

In recovery from nerve injuries the muscles supplied by the external popliteal branch recover more slowly, as a rule than do those supplied by the internal popliteal The order of return of function following internal popliteal (tibial) nerve injury is the gastrocnemius, tibialis posticus peronei tibialis anticus, flexor longus digitorum and the flexors of the toes

Obstetrical Paralysis of the Long Thoracic or Posterior Thoracic Nerve —Ridlon and Berkheiser reported a case of paralysis of the long thoracic nerve with winged scapula, which occurred during delivery The cause was prolonged forcible pulling on straps attached to the foot of the bed

Fahrni reviewed the literature on **congenital paralysis of the sciatic or popliteal nerves** Bernherdt *observed several cases of palsy in the area of* distribution of the sciatic nerve after extraction by the foot Michaelis reported the case of a child, aged six weeks, who had complete paralysis of the lateral popliteal nerve from birth The delivery had been normal

Lust and Berrewaerts reported the case of a child who was delivered by lower segment Cæsarean section after the mother had been in labor for twenty-four hours The pelvis was contracted The child was healthy but *the right foot was swollen and there was a complete lesion of the lateral* popliteal nerve which recovered in twenty days They concluded that this was "a case of obstetrical paralysis due to faulty intra uterine position with compression"

Fahrni saw 11 cases of **neonatal sciatic paralysis** Asphyxia was the constant feature in all his cases He noticed that the routine treatment of neonatal asphyxia included the injection of a certain proprietary drug into *the umbilical cord*

Twenty cases of unilateral sciatic paralysis, sometimes accompanied by cutaneous gangrene of the ipsilateral buttock, have been seen in newborn infants in the maternity departments of two hospitals in Liverpool

The lesions are compatible with the results of ischemia due to disturbance of blood flow in the internal iliac artery, and are comparable to the lesions produced by intra-arterial injection of thiopentone

PERIPHERAL NERVE WOUNDS OF THE LOWER EXTREMITIES

When the sciatic nerve is severed, there is a paralysis of all the muscles below the knee The fibers to the biceps femoris semimembranosus and semitendinosus are often spared There is loss of sensation over the outer border of the leg and over the whole foot except the inner surface proximal to the sole

When the peroneal nerve is severed, the foot hangs in a plantar flexed position known as foot-drop The patient is unable to flex or extend the toes or the foot, or to evert the foot Inversion is possible by the feeble action of the tibialis posticus supplied by the tibial nerve The sensory loss extends over the outer border of the leg a strip over the dorsum of the foot from the inner two or two and-a-half toes to a line in the middle of the outer surface of the great toe and the great and adjacent toe Because of overlap of nerve supply a narrow strip over the dorsum of the foot is sometimes the only area completely anesthetic

NERVE COMPRESSION AND PARESTHESIAS

Experiments show that, in addition to causing ischemia, nerve compression increases the paresthesia The ischemic and postischemic conditions of the nerve trunk are responsible for paresthesias Erhart's experiments

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of the distribution of the median and sciatic nerves It is caused by lesions of these nerves at points more or less distant from the areas mentioned, and is characterized by local vasomotor disturbances and general hypersensitiveness of the nervous system Christopher called it a painful vasomotor neurosis, due to irritation of a mixed nerve

This condition may occur in the upper or lower extremity, affecting chiefly the median and the internal popliteal nerves It is characterized by intense pain, which is increased by palpation, movement or any slight pressure, even that of the bed-clothing Most of my own experience with this lesion was obtained in the French Army Hospitals in Le Mans, with Delageniere, Tinel and Jacquemin

The fundamental lesion is an interneural and perineural sclerosis or fibrosis Gynergen may relieve the pain The intraneural injection of a 60 per cent solution of alcohol, as suggested by Sicard, has given satisfactory results when neurolysis alone might not have given relief The operative treatment is neurolysis or freeing the nerve from scar tissue In some cases it is necessary to resect the nerve and suture the ends After nerve suture it is necessary to relax the tension as much as possible by placing the limbs in various positions In nerve suture, end-to-end anastomosis is the most likely method to succeed The nerve ends must be treated gently, and it is important in suturing, that the nerve should not be rotated

TUMORS OF THE SPINAL CORD

As early as Hippocrates, operations on the spinal column had been advised for the relief of pressure on the spinal cord, subsequent to trauma Hildanus also urged that this be done, but it was not until 1814 that Cline successfully removed the arch of a compressing vertebra Little attention was paid to this type of surgery until McEwen operated upon a man in whom complete paraplegia had developed after an injury to his back

In 1887 Gowers and Horsley diagnosed and successfully removed an intraspinal tumor

Since the days of Sir Victor Horsley the surgery of intraspinal lesions has been greatly simplified Asepsis, anesthesia, antibiotic agents, hemostatics and technical apparatus such as the electrosurgical unit have combined to make surgery of the column more precise and attended by a markedly lessened risk

The Historical Aspects of Spinal Cord Tumors —For several hundred years spinal cord tumors have been known to produce definite and serious neurologic symptoms It was not until 1888 however that neurologic localization and surgical technics developed sufficiently to allow Horsley to remove successfully a benign spinal cord tumor which had been correctly diagnosed and localized by Gowers Since then many advances have been made to aid in an earlier diagnosis and more exact localization of these tumors The perfection of roentgenologic technics and interpretation has made roentgenograms extremely valuable The introduction of lumbar puncture as a diagnostic procedure by Quincke in 1891 and the observations of Froin on xanthochromia and Queckenstedt and Ayer on spinal fluid dynamics have helped considerably in earlier diagnosis and in some cases,

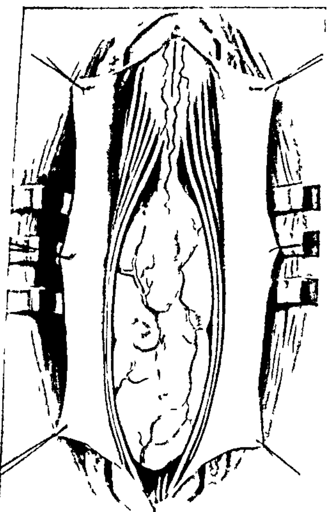
In injuries of the external popliteal (common peroneal) nerve, recovery occurs in the tibialis anticus, peronei, extensor *longus digitorum and* extensor proprius hallucis in that order

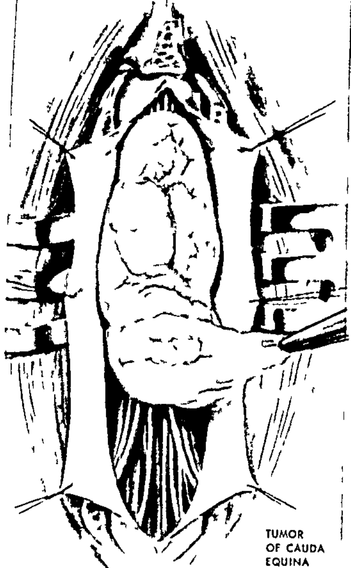


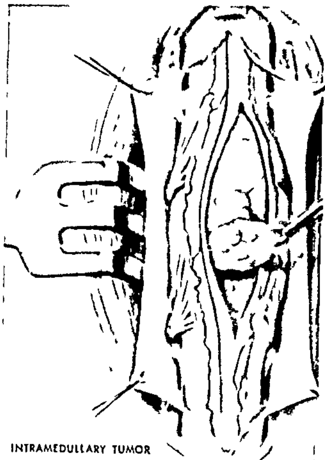
Fig 319 —Sciatic nerve exposed by separation of fibers of gluteus maximus and division of lower insertion of muscle Muscle retracted medially together with large gluteal vessels Suture of *nerve and branches (From Stookey Surgical and Mechanical Treatment of Peripheral Nerves* courtesy of W B Saunders Co)

MacCarty reported a successful graft of the peroneal division of the sciatic to repair an extensive destruction of the main nerve The autograft of the nerve is analogous to a pedicled skin graft

Causalgia —The first case of causalgia was reported in 1813 by Denmark, but it was not until 1864 that S Weir Mitchell gave a complete and classic description of the disorder Causalgia (thermalgia) is an intensely painful neurocirculatory condition almost entirely limited to certain sensory areas







Spinal Cord Tumors (From *Ciba Collection of Medical Illustrations Vol I—The Nervous System*)

localization of cord tumors Finally, according to Craig, Moersch and Christopherson, the advent of contrast myelography, first with air as proposed by Dandy in 1918 and later with iodized oil, as introduced by Sicard and Forestier in 1922, and with pantopaque by Steinhausen and associates, has made precise localization possible by mechanical means Thus the neurologist is concerned not only with the localization of cord tumors, but also with the early diagnosis and differential diagnosis

Early recognition of intraspinal lesions is important in minimizing pain and disability and in preventing or restoring impairment of function Radicular pain is the chief symptom which forces the patient to consult his physician

The diagnosis of lesions of the spinal cord is not always simple It can be made and operation can be carried out before serious permanent disability occurs Examination of the cerebrospinal fluid and visualization of the spinal canal by means of opaque media furnishes valuable diagnostic aid

Spinal cord tumors occur in the cervical, thoracic and lumbar regions, *the cauda equina and the filum terminale They are divided into* extra- and intradural growths Intradural growths may be extra- or intramedullary The majority of tumors of the spinal cord are benign and operable They may be derived from the tissues of the vertebral column, the spinal canal, meninges and spinal cord and may arise at any level

Symptoms —The symptoms of spinal cord tumors are motor and sensory Motor symptoms include early spasticity and late flaccidity Sensory disturbances to pain, temperature and pressure are cardinal signs Pain is usually not an early symptom Local and referred pain are characteristic Rigidity of the spine is an early sign

The characteristic symptoms and signs that were formerly thought to indicate the presence of a spinal cord tumor are being taken over "bodily" in diagnosing a disk syndrome The chief exceptions are (1) intermittency of symptoms (2) response to recumbency, (3) spinal fluid studies, (4) myelographic findings

Moersch Craig and Christopherson find that the importance of a knowledge of the early symptoms and signs of spinal cord tumors cannot be overemphasized With the modern diagnostic aids and perfected surgical technics many spinal cord tumors can be demonstrated and removed before serious neurologic deficit occurs

Disturbance in Urinary or Bowel Function —A history of urgency frequency or incontinence of urination

Hyperactive Reflexes —Hyperactive reflexes indicate pressure on a pyramidal tract and are not found in protrusion of a lumbar disk However, a tumor of the spinal cord involving the lumbar segments of the cord, will produce this finding when the stage of compression of the cord has been reached The activity of the reflexes in the lower extremities should be checked against those in the upper extremities

Spasticity —The presence of spasticity points to involvement of the spinal cord Generally hyperreflexia and spasticity are found concomitantly

Muscular Atrophy —Muscular atrophy occurs in only 2 per cent of cases of lumbar protruded disks but is common in cases of spinal cord tumors involving lumbar segments

Sensory Involvement.—The sensory involvement produced by a protruded lumbar disk involves generally only a portion of one dermatome.

Overlapping of Signs and Symptoms.—Craig, Camp, and Shelden found that spinal cord tumors produce symptoms and signs that occur characteristically in cases of protruded lumbar disks.

Roentgenographic Examination.—Changes indicative of erosion, secondary to direct pressure from benign tumors, and invasive destruction caused by primary malignant or metastatic malignant lesions, must be carefully searched for in the roentgenograms.

Intraspinal Investigation.—Intraspinal investigation, including analysis of spinal fluid, and contrast myelographic studies or, in some cases, differential spinal puncture are always of great value.

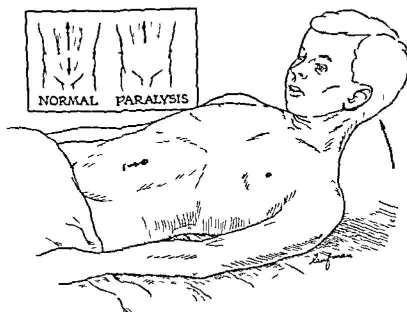


Fig. 320.—Beevor's sign in case of paralysis of lower abdominal muscles. Upward excursion of umbilicus when head is raised localizing lesion between the 8th and 10th thoracic spinal segments. (Lewin's Infantile Paralysis, courtesy of W. B. Saunders Company.)

Disturbances of Mobility.—The patient may become aware of clumsiness in running, or of slowly progressive muscular weakness, whose causes are usually due to injury of the corticospinal pathway, the pyramidal tract or an upper motor neuron. The homolateral muscles below the level of the tumor become weak and spastic, the tendon reflexes are increased, and Babinski's sign is present. The tips of the patient's shoes may show a decided difference in wear, due to an asymmetrical tread.

Disturbances of Sensation.—The patient may complain that his underwear is unbearably irritating, his feet may be wobbly, the limbs may move to unanticipated positions, there may be burning, tingling or a "woody sensation."

Disturbances of Sphincteric Control.—Disturbances in the sphincteric and sexual functions are sources of irritation to the patient.

Beevor's sign is invaluable. When a lesion is located at the level of the 8th, 9th or 10th thoracic spinal segments, the lower portion of the rectus

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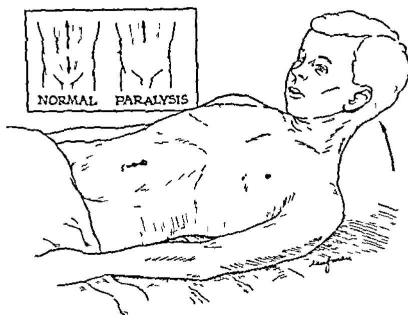


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muscles may be weakened or paralyzed, consequently, when the supine patient is directed to raise his head from the bed, the umbilicus moves upward because it is pulled up by the upper part of the rectus which is intact

Reflexes below a compression lesion of the cord are increased, the patient is spastic, and all the pathological reflexes may be observed, ankle and patellar clonus, Oppenheim and Babinski reflexes

The most valuable test of a focal lesion is the sensory examination

The Queckenstedt test is usually positive in the presence of a tumor The cystometric studies of Rose are of great help in differentiating lesions above the bladder center in the cord, lesions of the bladder center and lesions in the peripheral mechanism

Craig feels that the most important part of the examination is a careful evaluation of the changes in motion and sensation Changes in reflexes and atrophy of muscles individually and in patterns sometimes lead to a solution of a complicated problem The statement that the patient was awakened from a sound sleep in the early morning hours by a pain, which could be relieved by getting up and sitting in a chair, should make the examiner suspicious

A transverse lesion of the spinal cord may occur suddenly without prodromal symptoms and produce a syndrome indistinguishable from tumor compression

The usual motor and sensory tests, together with the Queckenstedt test are usually adequate to make the diagnosis

A careful history and neurological examination are sufficient for both diagnosis and localization in over 90 per cent of cases of spinal-cord tumor By using air or pantopaque the diagnosis and localization can be made in the remaining 10 per cent

Davis called attention to the fact that loss of the deep tendon reflexes, a flaccid paralysis, muscular atrophy and a reaction of degeneration, mean the presence of a lower motor neuron lesion There can be only three sites for such a lesion the peripheral nerves the anterior roots and the anterior horn cells of the spinal cord The loss of sensation will rule out a peripheral nerve lesion Anterior root lesions are so rare that they may be practically disregarded The anterior horn cells are left This is a horizontal diagnosis, and the muscles involved will afford the vertical or segmental level diagnosis A spinal cord tumor requires differentiation from every degenerative disease of the spinal cord Manometric studies include the Queckenstedt test Demonstration of the presence of a subarachnoid space block is of extreme importance Study of the protein content of the fluid above and below a tumor is often a deciding diagnostic factor

Camp and Adson found that roentgenographic studies, with radiopaque oil, have furnished additional information leading toward localization of small tumors in some cases before positive neurological symptoms have appeared These studies assist in distinguishing arachnoiditis, intradural, extradural and intramedullary tumors and atrophic lesions of the spinal cord

The data obtained by spinal puncture and by roentgenological and rectal examinations usually prevent serious diagnostic errors Roentgenography occasionally reveals erosion of bone produced by a tumor or even a calcified tumor

Certain symptoms and signs are more suggestive of tumor than of a disk lesion. In Allen's patients an insidious onset of pain without a history of trauma, and an unremitting course definitely suggested tumor. The initial symptoms of numbness in both legs is more frequently associated with tumor, as is early weakness of the lower extremities, especially when this is bilateral. Bladder and rectal disturbances usually appear late. A large disk herniation appearing rapidly after trauma may immediately produce bladder and rectal changes.

Patients with tumor are not so likely to have remissions as are patients with disk lesions. Pain that is constant, unrelieved by recumbency and severe enough to prevent sleep at night is more commonly associated with tumor. The patient with a ruptured intervertebral disk usually has recurrent attacks of sciatica. He is usually able to obtain relief from pain while in the recumbent position.

Symptoms and Physical Signs in Tumor Cases (Allen)

Symptoms	No	Signs	No
Low back pain	24	Absent or diminished ankle jerk	27
Unilateral sciatica	17	Sensory changes	24
Paraesthesia	15	Muscle atrophy	21
Weakness of legs	15	Positive straight-leg raising test	19
Leg pain, other than sciatica	13	Muscle spasm in lumbar spine	11
Urinary and rectal symptoms	10	Limited motion in lumbar spine	9
		Increased reflexes	7
Night pain	5	Absent or diminished knee jerk	6
Bilateral sciatica	3	Positive Babinski	4

Signs and Symptoms. — The cardinal symptom of tumor is pain which may continue for a long time before other neurological signs appear. Pain in the lower extremities is characteristic of lesions of the cauda equina. The pain radiates to the back or the front of the thighs or to the perineum or it may be sciatic in nature. Sometimes it is restricted to the small of the back. Later symptoms are muscle weakness, flaccid paralysis and impairment of all forms of sensation. Wechsler found that patients with low-spine lesions have relatively late involvement of the bladder and rectum, as well as late saddle anesthesia. If the lesions are higher, i.e., in the conus medullaris, the bladder and rectal changes appear early and may be severe. Saddle anesthesia is present, ankle jerks are absent, the power of erection and ejaculation in the male is impaired, and there may be loss of pain and temperature sense. In lesions of the epiconus, paralysis of the muscles of the feet may appear early.

The average duration of symptoms from onset to date of operation in Love's series was twenty five months. The most common presenting symptom was low back pain. The next most frequent symptom was unilateral sciatica followed by numbness of the legs. In addition 6 patients had the primary complaint of vague leg pain and two had the initial complaint of weakness of the legs. Usually rectal and urinary symptoms appeared late.

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The data obtained by spinal puncture and by roentgenological and rectal examinations usually *prevent serious diagnostic errors* Roentgenography occasionally reveals erosion of bone produced by a tumor or even a calcified tumor

Certain symptoms and signs are more suggestive of tumor than of a disk lesion. In Allen's patients an insidious onset of pain without a history of trauma, and an unremitting course, definitely suggested tumor. The initial symptoms of numbness in both legs is more frequently associated with tumor as is early weakness of the lower extremities, especially when this is bilateral. Bladder and rectal disturbances usually appear late. A large disk herniation appearing rapidly after trauma may immediately produce bladder and rectal changes.

Patients with tumor are not so likely to have remissions as are patients with disk lesions. Pain that is constant, unrelieved by recumbency and severe enough to prevent sleep at night is more commonly associated with tumor. The patient with a ruptured intervertebral disk usually has recurrent attacks of sciatica. He is usually able to obtain relief from pain while in the recumbent position.

Symptoms and Physical Signs in Tumor Cases (Allen)

Symptoms	No.	Signs	No.
Low back pain	24	Absent or diminished ankle jerk	27
Unilateral sciatica	17	Sensory changes	24
Paresthesia	15	Muscle atrophy	21
Weakness of legs	15	Positive straight leg raising test	19
Leg pain, other than sciatica	13	Muscle spasm in lumbar spine	11
Urinary and rectal symptoms	10	Limited motion in lumbar spine	9
Night pain	5	Increased reflexes	7
Bilateral sciatica	3	Absent or diminished knee jerk	6
		Positive Babinski	4

Signs and Symptoms.—The cardinal symptom of tumor is pain, which may continue for a long time before other neurological signs appear. Pain in the lower extremities is characteristic of lesions of the cauda equina. The pain radiates to the back or the front of the thighs or to the perineum or it may be sciatic in nature. Sometimes it is restricted to the small of the back. Later symptoms are muscle weakness, flaccid paralysis and impairment of all forms of sensation. Wechsler found that patients with low-spine lesions have relatively late involvement of the bladder and rectum as well as late saddle anesthesia. If the lesions are higher, i.e., in the conus medullaris, the bladder and rectal changes appear early and may be severe. Saddle anesthesia is present, ankle jerks are absent, the power of erection and ejaculation in the male is impaired, and there may be loss of pain and temperature sense. In lesions of the epiconus, paralysis of the muscles of the feet may appear early.

The average duration of symptoms from onset to date of operation in Love's series was twenty-five months. The most common presenting symptom was low-back pain. The next most frequent symptom was unilateral sciatica, followed by numbness of the legs. In addition, 6 patients had the primary complaint of vague leg pain and two had the initial complaint of weakness of the legs. Usually rectal and urinary symptoms appeared late.

Six patients had no pain at any time The primary complaint was numbness of the lower extremities Spurling and Mayfield found that 26 per cent of 42 patients with neoplasm of the spinal cord had no pain

The most common single physical sign in Love's series of tumors was absence or diminution of ankle jerks Next were objective sensory changes Since many of these physical signs are commonly found in intervertebral disk lesions, it may be impossible to distinguish between tumors and disk lesions on the basis of the symptoms and physical signs alone In fact, tumors may become very extensive, with little change in the lower extremities This is illustrated by 4 of Love's cases, in which the neurological examination was completely negative

Allen found no sensory changes in 23 per cent of his cases

Roentgenographic Studies —The most important single aid in the diagnosis of cauda equina lesions is the myelogram In many cases, the history and physical findings are indecisive, but the use of contrast media establishes the differential diagnosis between a tumor and a disk lesion

In a two-year period a total of 1,296 patients were operated on at the Mayo Clinic for intraspinal lesions situated at the level of the 10th thoracic vertebra or lower Of this number 51 patients had tumors and 3 had arachnoiditis Of the 51 who had tumors, 24 gave evidence of tumors from the outset In 20 of the remaining 27 cases, the presumptive diagnosis made from the initial history and neurological, orthopedic, and roentgenographic examination was protruded lumbar intervertebral disk In the remaining 7 cases, although a working diagnosis of a protruded disk was made the possibility that the lesion might be an intraspinal tumor was entertained The chief reasons for including the alternate diagnosis of spinal cord tumor were one or a combination of the following features (1) history of night pain, (2) presence of marked scoliosis or kyphoscoliosis, (3) presence of a primary malignant lesion elsewhere in the body

Craig finds that if more than 100 mg of total protein is found in the cerebrospinal fluid the offending lesion is considered to be a spinal cord tumor until proved otherwise

In all of these 27 cases contrast myelography with air or radiopaque oil was employed By this means a diagnosis of intraspinal tumor was established in all but 4 cases

Diagnosis —The diagnosis is based on the history and physical findings, including motor and sensory disturbances Spinal fluid tests include lumbar puncture manometric, cisternal and combined cisternal and lumbar manometric tests Exaggeration of symptoms following lumbar puncture helps to establish the diagnosis of a space-occupying lesion of the spinal cord

Interpediculate Distance —Roentgenograms of the spine taken in the antero-posterior position are often most helpful in determining changes in the size of the spinal canal Elsberg and Dyke found that the width of the vertebral canal can be accurately determined from the roentgenogram by measuring the shortest distance between the medial borders of the pedicles of each vertebra This is known as the interpediculate distance and is fairly constant for each segment

The studies of Elsberg and Dyke on the shape of the pedicles of the vertebrae and measurements of the size of the vertebral canal indicate

that it is possible in a number of instances not only to make the diagnosis of spinal cord tumor but also to determine the location and the approximate size of the neoplasm, from the roentgenograms. Clinical findings may then be confirmed and indicate exactly where the operation should be performed. Diagnosis and localization of the lesion are possible even when the case history and the results of neurological examinations leave room for doubt as to the nature and situation of the lesion.

The factors on which a diagnosis is based, are: (1) bone destruction, (2) appearance of and measurement between the pedicles, (3) distortion of the paraspinal tissues, (4) bone proliferation, (5) abnormalities of the intervertebral disks, (6) kyphosis and scoliosis, (7) calcification.

Aside from negative roentgen changes in the body of a vertebra, there seems to be no decisive differential objective evidence between a tumor and other causes of sciatic neuritis.

Spinal cord tumors cause motor defects and pain, paresthesia or loss of sensation. If the tumor is near a nerve root, a typical radicular syndrome is the result; as examples Williams offers the following:

A tumor at the level of C 1, 2, 3 and 4 causes pain in neck, postauricular area and top of shoulder.

A tumor at the level of C5, 6, 7 and 8 causes pain in the arm.

A tumor at the level of L1, 2 and 3 compresses the spinal cord and roots causing pain in the back, the anterior surface of the thigh and upper leg.

Lumbosacral tumors cause backache, sciatica and perineum pain.

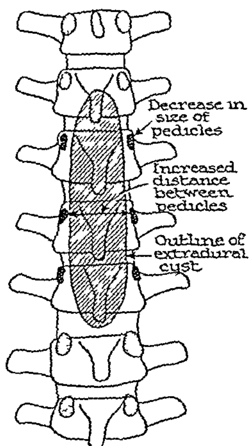


Fig. 321.—Diagrammatic reconstruction form roentgenogram showing changes resulting from extradural cyst. Note increased distance between pedicles and decreased size of pedicles in region of cyst. (After Elsberg, Dyke and Brewer.)

Tumors of the filum terminale or cauda equina cause pain in the small of the back, the sciatic distribution or perineum.

Allen found that 1 in 10 spinal cord tumors affects the cauda equina. Tumors may grow within the canal for a long time without producing neurological signs because of the width of the sacral canal.

Love reviewed 26 cases of spinal cord tumor which "masqueraded" as protruded intervertebral disks. Cohen and Kaplan, noted the similarity of the clinical picture in a group with cauda equina tumor and in the intervertebral disk cases.

Because of the similarity between the clinical picture of tumors and disks surgeons must be on guard in treating a cauda equina tumor with heat and

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Intractable Pain Not Relieved By Conservative Management.—Continuous pain that is not relieved by conservative treatment should arouse suspicion that a tumor is present.

Persistent Pain After Operation for a Protruding Disk.—Craig *et al.* reported the removal of a spinal cord tumor from each of three patients who had had a previous operation for protruding disk, without relief of symptoms.

For about every 25 operations performed for protruded lumbar intervertebral disk at the Mayo Clinic, one operation is performed for spinal cord tumor that it is so situated that at some time during its course, it could simulate a protruded lumbar disk.

Owing to the disparity in length between the spinal cord and the vertebral axis, the lumbar segments of the cord lie at the level of the 10th, 11th and 12th thoracic vertebrae, and the nerve roots originating from these lumbar segments of the cord, pass obliquely downward to make their exit through their respective intervertebral foramina.

Intraspinal tumors can be conveniently classified into three categories as follows: Intramedullary, intradural and extramedullary, extradural.

Persons with tumors of the central nervous system usually by-pass the orthopedic surgeon and gravitate directly to the neurosurgeon. Every person who complains of root pain or of progressive motor or sensory disturbance of the extremities should be examined thoroughly.

Woltman found the patient's story a most important aid in diagnosis. The earliest and commonest complaint is pain, which may be in the spine at the site of the tumor, or referred to the lower extremities even when the tumor lies high in the canal. Usually it is referred along the distribution of a posterior root and is called "root pain." The peripheral radiation of root pain and its various qualities, aching, squeezing or piercing, frequently suggest disease of the pericardium and pleura, of the biliary, urinary and gastro-intestinal tracts, of the peripheral nerves, or of muscles and bones.

Root pains are segmentally distributed, *i. e.*, lengthwise in the arms and legs and circularly in the trunk. The pain may become more and more intense and adjacent roots may become involved, unilateral sciatica may become bilateral and unilateral trunk pain has a superimposed complementary pain on the opposite side, completing the so-called "girdle." There is, as a rule, no local tenderness. Coughing, sneezing, compression of the jugular veins or anything which suddenly increases the pressure of the spinal fluid aggravates the pain. Root pains tend to waken the patient from sleep at three or four o'clock in the morning. Relief may be obtained by walking, or by sleeping in a chair. A helpful test consists in flexing the head sharply on the thorax. This often elicits or accentuates the resulting traction on the cord and dura increasing congestion within the head which displaces cerebral fluid into the spinal canal.

Bilateral sciatic pain should be regarded as caused by a tumor or a protruded disk unless other causes can be proved.

The diagnosis should be made as early as possible. The clinical diagnosis can be confirmed by laboratory examinations for modifications of the cerebrospinal fluid, the pressure of the fluid and the radiological examination of the subarachnoid space after injection of a contrast medium which outlines the tumor.

massage, belts and braces, postural training and exercise, or even by spine fusion and disk exploration

Differential Diagnosis.—The differential diagnosis may be difficult. Clinical symptoms are those of compression of the spinal cord. Roentgenographic changes are characteristic.

As symptoms, Love listed enlargement of the canal, erosion of pedicle, lamina or body, the posterior vertebral border curved and possibly broken. When the tumor is malignant, direct infiltration and destruction are present. Various inflammatory, malignant and post-traumatic lesions of the spinal cord, membranes, roots and spinal column come into question, as do degenerative diseases of the cord. Multiple sclerosis may suggest a transverse lesion of the cord and since it may be simulated by tumors high in the vertebral canal. Syringomyelia may be difficult to distinguish from intramedullary tumor, and the two may be present in the same person. The spinal cord and roots may be compressed in hypertrophic arthritis of the spinal column and in Paget's disease. Spina bifida occulta may be associated with traction and compression bands that lead to progressive paralysis and even tumor. Malignant transformation, neoplasm of bone and tuberculosis of the spine also must be considered.

The loss of the patellar reflexes in cases of tumor sometimes may lead to the erroneous diagnosis of tabes. Root pains cause the greatest confusion.

The Key Points in Differential Diagnosis

1. History and Symptoms
   (*a*) Intermittency
   (*b*) Response to Recumbency
2. Neurologic Examination
3. X ray findings (+) or (—)
4. Cerebrospinal fluid findings—(protein)
5. Myelogram
6. Therapeutic test

The symptoms of the syndrome of herniated intervertebral disk are similar to those of intraspinal tumor.

Studies of the hydrodynamics of the cerebrospinal fluid and chemical examination, contrast media and careful neurologic examination are prerequisites.

Craig and his associates believe that the true nature of the lesion can generally be determined by careful consideration of certain factors in the history and examination.

Night Pain.—A patient harboring a spinal cord tumor will often experience radicular pain four or five hours after recumbency. This pain is severe enough to awaken him from sleep. In order to obtain relief he finds it necessary to walk the floor and frequently he finishes his night's sleep sitting in a chair. The mechanism of this pain is thought to depend on the lengthening of the vertebral axis in recumbency with consequent pulling on the involved nerve roots due to the ballooning of the intervertebral disks, which in the recumbent position are released from bearing weight

became evident and its location was usually established. In those instances in which intraspinal investigation did not establish the true nature of the lesion, myelographic study with a contrast medium did localize the lesion accurately. By analysis of spinal fluid and contrast myelographic studies a significant number of errors was avoided.

Love states categorically, that a protruded intervertebral disk is the commonest intraspinal lesion that produces sciatic pain. Hypertrophic arthritis, spondylolisthesis, spondylolysis, old fractures and dislocations, tumors of the spinal cord and nerve roots, metastatic bone lesions, tuberculosis of the spinal column, and thickening and fibrosis of the ligamenta flava also produce sciatic pain. The frequency with which operative interference is necessary in this miscellaneous group of conditions is small in comparison with that for protruded intervertebral disk.

In the five-year period from 1939 to 1943 at the Massachusetts General Hospital, the diagnosis of ruptured disk was verified at operation in 330 cases. During that same period there were 15 cases of proved conus and cauda equina tumors—a relative incidence of approximately 4 per cent.

Barr emphasizes that in any given case of low-back pain and sciatic pain, the decision to operate should be made on all the available evidence. The history and physical findings are of paramount importance. The laboratory findings should be carefully interpreted in the light of the clinical picture. Myelography gives important evidence, even when it is negative, for a negative myelogram practically rules out a spinal cord tumor.

Several patients who had unsuccessful operations for ruptured intervertebral disks, have had tumors found at a subsequent operation at Barr's Clinic. There is one way by which such catastrophies can be avoided—*viz.*, routine myelography.

DUMBBELL (HOURGLASS) NEUROFIBROMAS AFFECTING THE SPINAL CORD

Love and Dodge reported that 60 cases of dumbbell neurofibroma which affected the spinal cord and adjacent paraspinal structures have occurred in 1,000 cases of neoplasm of spinal cord for which operation has been performed at the Mayo Clinic since 1914.

Characteristically the spinal part of these tumors produced the symptoms of cord compression when they occurred in the thoracic portion of the spinal cord. At the lumbar and lumbosacral levels the symptoms were those of progressive failure of a nerve root, while at the cervical level the symptoms often were those of a combination of root failure and compression of the spinal cord.

Dumbbelling of these tumors occurred most frequently on the dura mater and through the intervertebral foramen.

Most commonly roentgenologic evidence of the dumbbell tumor consisted of an enlarged smoothly eroded intervertebral foramen. Examination of the cerebrospinal fluid frequently revealed obstruction of the subarachnoid pathways of the spinal fluid and a value of more than 100 mg. of protein per 100 cc. of spinal fluid. Pathologically all the tumors were neurofibromas. Most of the dumbbell neurofibromas affecting the spinal cord lent themselves to one-stage removal.

Tumors of the spinal cord simulate many lesions especially protruded disks In the presence of Pott's disease or some types of myelitis it is possible to make a mistaken diagnosis of tumor of the spinal cord In *certain cases it is impossible to distinguish whether or not the pathological* process is a neoplasm or an inflammatory lesion

Due to the disparity in length between the spinal cord and the skeletal axis, some of the nerves which comprise the sciatic trunk make their exits from the spinal cord as high as the level of the tenth or eleventh thoracic vertebrae Svien and Dodge emphasize the fact that involvement of these nerves in the spinal canal, anywhere between their points of origin and their exits through their respective intervertebral foramina, may give rise to low back and sciatic pain

During a period of three years, 1,242 patients were operated upon at the Mayo Clinic for removal of herniated lumbar disks Dodge, Svien, Camp and Craig report that 12 patients initially suspected of having herniated intervertebral disks underwent examination with completely negative results, but were later found to have tumors of the spinal cord

One of the most baffling groups of cases in which the primary complaint is low-back and sciatic pain simulating the pain of protruded intervertebral disks, is that in which intraspinal tumors produce no neurologic signs or symptoms The history of trauma may be misleading Pain may be intermittent and intense

Unilateral sciatic pain was present in 75 per cent of cases of herniated disks and in 38 per cent of cases of intraspinal tumors situated at a low level Bilateral sciatic pain was present in 15 per cent of the cases of herniated disks and in 23 per cent of the cases of intraspinal tumors Low-back pain was complained of by 95 per cent of the patients with protruded intervertebral disks and by 42 per cent of those who had intraspinal tumors Nocturnal pain which necessitated the patient's getting up and moving about for relief and which at one time was thought to be pathognomonic of intraspinal tumor was reported by 21 per cent of patients with herniated disks and by *47 per cent of those who had intraspinal tumors Loss of both* vesical and rectal sphincter control was found in 5 per cent of the cases of herniated disks and in 33 per cent of the cases of intraspinal tumors Sensory loss, or changes in the sensory pattern involving the lower extremities, occurred in 22 per cent of the cases of herniated disks and in 64 per cent of the cases of intraspinal tumors Atrophy of the muscles of the lower extremities was recorded in 2 per cent of the cases of herniated disks and in 42 per cent of the cases of intraspinal tumors

From a study of 1,296 cases in which operation was performed at the Mayo Clinic for intraspinal lesions at or below the level of the 10th thoracic vertebra, Craig Svien, Dodge and Camp found that the symptoms and signs of spinal cord tumors that originated at the level of the 10th thoracic vertebra or lower, simulated those of a protruded lumbar intervertebral disk In these cases the true nature of the lesion producing the signs and symptoms could not be determined from the history and neurological, orthopedic, or simple roentgenographic examination However when intraspinal investigation, consisting of analysis of spinal fluid and contrast myelographic studies, was carried out the presence of an intraspinal tumor

qualified thoracic, abdominal or pelvic surgeon. Dumbbell neurofibromas (neurilemmomas) are extremely benign. The prognosis for recovery after complete removal of the tumor is excellent.

Neuroblastoma.—Twelve undifferentiated neuroblastic tumors (sympathico-blastomas) involved the spine in Bucy and Camp's series. Such a tumor is usually situated in the lower part of the thoracic or in the lumbar region. It destroys bone and produces a paravertebral shadow. It tends to metastasize to the regional lymph nodes and to other bones. On microscopic examination it is often mistaken for Ewing's sarcoma and, like Ewing's tumor, responds to irradiation.

A glial or nerve sheath tumor of the spinal cord may involve the vertebral column. A meningeal tumor usually affects the thoracic or the cervical vertebrae and may be recognized either because of erosion of bone or calcification in the tumor. Neurinoma is most common in the lumbar and the sacral region. This benign tumor attached to a nerve root may slowly erode the pedicle, a lamina or the body of the vertebra, in the order mentioned. Erosion is more rapid and more pronounced when a malignant nerve sheath tumor affects the roots of the spinal nerves. Glial tumors that produce changes in bone are rare. They are usually primitive neuro-epitheliomas or ependymomas. In the sacrococcygeal region a benign or malignant teratoma may erode bone.

A *sympathetic neural tumor* may arise from any of the types of cell described in the differentiation of the neuroblast. Sympathogonia and sympathoblasts are commonly present in the same tumor. All three types may be present.

Glial tumors and tumors of the neural sheath and of the meninges may be difficult to distinguish pre-operatively from other neoplastic lesions of the spine. Primary or paravertebral tumors of the spine may cause neurological symptoms as the first and only complaint. As a rule, however, intramedullary tumors and benign tumors of the nerve sheaths may be diagnosed by prominent neurological features, and by the changes in bone.

TUMORS OF THE CAUDA EQUINA

Disorders of the cauda equina may produce subjective symptoms identical with those of peripheral nerve disease. A tumor of the cauda equina is characterized by progressive sensory, motor and sphincter paralysis and loss of reflexes. The symptoms are: burning pain in the perineum, radiating pain increased by recumbent posture and relieved by walking, severe constipation. The diagnosis of lesions of the cauda equina can often be made by the intrathecal use of pantopaque which localizes the upper level of the lesion. Cushing and Ayer at operation found xanthochromia below the tumor and above the tumor, even as high as the cisterna magna. Rapid progression of these signs and the severe pain in the back, the rigid lumbar spine due to spasm of the erector spinae muscles, and the marked tenderness over the spinous processes and laminae of the lumbar vertebrae, make metastatic carcinoma of the body of the vertebra the most likely diagnosis. Absence of roentgenologic changes in the body of the vertebra

In the case of ependymomas arising from the filum terminale and producing low back or sciatic pain, or both, it is essential to perform laminectomy of sufficient extent to permit resection of all involved tissue

In closing laminectomy wounds, hemostasis is next in importance to asepsis Without the one, paralysis is likely to occur and without the other, death

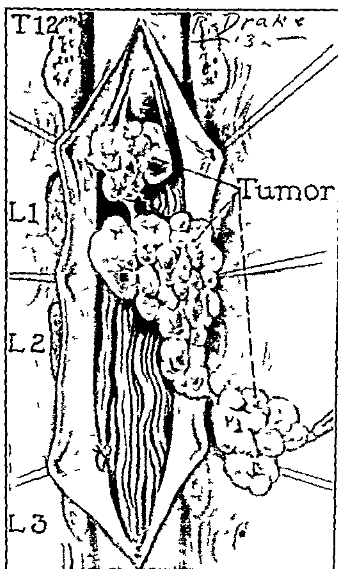


Fig 322 —Multiple attached neurofibromas Drawing representing tumor exposed and partially removed at operation (Camp courtesy of Am Jour Roentg and Rad Therapy)

If the dura has been opened it should be sutured carefully, and it is a valuable aid in securing hemostasis to distend the dural sac with physiologic saline solution at a temperature of 100°F This distention compresses the extradural vessels and holds the dura against the bone, it also diminishes the chance of adhesions developing between the meninges and the spinal cord The edges of the resected bone should be sealed with bone wax Removal of some of these tumors may require the additional services of a

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are important in the differential diagnosis between this lesion and neoplasm of the body of the vertebra

Newer Signs of Cauda Equina Tumors —The most helpful spinal fluid tests are variations in dynamic pressures above and below a spinal cord tumor, which have been fully expounded by Ayer and others Viets found that jugular vein compression after drainage of the spinal fluid below the 'block,' causes intense pain in the anterior region of the thigh. The *pain stops immediately when the compression is removed The area of* the pain corresponds to the second lumbar root skin segment He also described the shifting of the pantopaque shadow when the patient changes from the upright to the prone position

In a report of 25 cases of glioma arising in the region of the cauda equina Kernohan Woltman and Adson found that pain was the initial complaint in more than 80 per cent of the cases

Bennett emphasized the importance of variable pain in the spine and nerve roots of extreme spasm of the erector spinae muscles followed by lateral deformities and of extreme bilateral spasm of the hamstring group *All these signs appear long before motor or sensory changes*

Toumey Poppen and Hurley emphasize the difficulties in the diagnosis of cauda equina lesions

They reported 48 cases of tumor of the cauda equina or low spinal cord in which operation was performed at the Lahey Clinic between 1939 and 1945 In this same time interval, 1,056 intervertebral-disk operations were performed The tumors represented 4 3 per cent of the entire group The patients with tumors ranged in age from fourteen to sixty-eight years

Early diagnosis is of paramount importance in the tumor cases There is great similarity in the clinical picture of tumors of the cauda equina *and disk lesions*

Insidious onset of pain with an unremitting course definitely suggests tumor Numbness and weakness of the legs is more often associated with tumor The duration of symptoms varies from two months to eight years The most common first complaint was low-back pain but 12 per cent of the patients had no pain whatsoever

The most common physical sign in the tumor cases was an absent or diminished ankle jerk but this finding is common in disk lesions also Tumor lesions cannot usually be differentiated from disk lesions by physical signs In 8 per cent of the tumor cases neurological signs were not present

The myelogram is the most significant and valuable aid in the differential diagnosis They prefer the use of pantopaque removed at the time of fluoroscopy

Estimations of total protein ranged from 14 to 610 milligrams per 100 cubic centimeters the average being 140 A protein determination of over 100 definitely suggests tumor and is a valuable diagnostic aid However, in 30 per cent of the patients who had tumors the total protein was not elevated

In their series, 20 per cent of the tumors were malignant Of the benign tumors neurilemmoma was by far the most common, with ependymoma second

SPINAL EXTRADURAL CYST AND KYPHOSIS DORSALIS JUVENILIS

Extradural cysts of the spinal cord which give rise to symptoms during adolescence are almost always associated with deformities of the thoracic spine, such as are seen in kyphosis dorsalis juvenilis

The clinical picture, as presented in 10 cases reported by Cloward and Bucy, is sufficiently constant and characteristic to permit recognition of this condition, pre-operatively, in the majority of cases Spinal extradural cysts arise in the lower mid-thoracic region of adolescent boys As a result of compression of the spinal cord, the cysts give rise to spastic paraplegia, with slight sensory changes and usually without pain or disturbances of the function of bowel or bladder They commonly are associated with kyphosis of the thoracic spine or with alterations in the vertebral bodies, are visible with the roentgen-ray and typical of the early changes in kyphosis dorsalis juvenilis, they may progress subsequently to the formation of a kyphosis

The initial symptom is almost invariably weakness in the lower extremities and difficulty in walking The pre-operative diagnosis in these cases is dependent upon recognition of an expanding intraspinal lesion in the presence of the early or advanced changes in the vertebral bodies characteristic of kyphosis dorsalis juvenilis As Scheuermann has pointed out the earliest change in the vertebral bodies is a rounding off of the antero-superior and antero-inferior corners Reduction in intervertebral space and collapse of the bodies give rise to a rounded kyphosis The presence of normal pedicles and an unenlarged spinal canal will indicate the absence of a cyst

To Scheuermann belongs the credit for having focused attention on this condition The disease usually appears in boys between the ages of fourteen and seventeen The kyphotic deformity is always rounded, is always self-arresting Scheuermann held the opinion that the condition is due not only to disturbances of the epiphyses but involves the cartilage lying between the intervertebral disk and the bone as well

Cloward and Bucy concluded that the association of a rounded thoracic kyphosis with spastic paraplegia is indicative of the presence of a spinal extradural cyst Roentgenograms will reveal the enlargement of the spinal canal and erosion of the vertebral pedicles All patients with kyphosis dorsalis juvenilis should be examined for neurological evidence of compression of the spinal cord and for roentgenologic evidence of enlargement of the spinal canal

Spinal Extradural Cysts —Dutoit and Faínsinger report that spinal extradural cysts are rare They reported the 25th to be recorded in the literature There appear to be two distinct clinical pictures associated with spinal extradural cysts Elsberg Dyke and Brewer (1934) defined the first the patient is an adolescent with the history and symptoms of progressive spastic paraplegia, radiographic examination shows thoracic kyphosis of the Scheuermann type with signs of an expanding tumor in the neural canal in the thoracic region This clinical type has been confirmed by Cloward and Bucy Adelstein Turnbull and Lehman The second type occurs in adults, usually in the thoraco-lumbar spine The cyst is not associated with thoracic kyphosis

are important in the differential diagnosis between this lesion and neoplasm of the body of the vertebra

Newer Signs of Cauda Equina Tumors —The most helpful spinal fluid tests are variations in dynamic pressures above and below a spinal cord tumor which have been fully expounded by Ayer and others Viets found that jugular vein compression after drainage of the spinal fluid below the "block," causes intense pain in the anterior region of the thigh The pain stops immediately when the compression is removed The area of the pain corresponds to the second lumbar root skin segment He also described the shifting of the pantopaque shadow when the patient changes from the upright to the prone position

In a report of 25 cases of glioma arising in the region of the cauda equina Kernohan Woltman and Adson found that pain was the initial complaint in more than 80 per cent of the cases

Bennett emphasized the importance of variable pain in the spine and nerve roots, of extreme spasm of the erector spinae muscles followed by lateral deformities, and of extreme bilateral spasm of the hamstring groups All these signs appear long before motor or sensory changes

Toumey Poppen and Hurley emphasize the difficulties in the diagnosis of cauda equina lesions

They reported 48 cases of tumor of the cauda equina or low spinal cord in which operation was performed at the Lahey Clinic between 1939 and 1948 In this same time interval, 1,056 intervertebral-disk operations were performed The tumors represented 4 3 per cent of the entire group The patients with tumors ranged in age from fourteen to sixty-eight years

Early diagnosis is of paramount importance in the tumor cases There is great similarity in the clinical picture of tumors of the cauda equina and disk lesions

Insidious onset of pain with an unremitting course definitely suggests tumor Numbness and weakness of the legs is more often associated with tumor The duration of symptoms varies from two months to eight years The most common first complaint was low-back pain, but 12 per cent of the patients had no pain whatsoever

The most common physical sign in the tumor cases was an absent or diminished ankle jerk but this finding is common in disk lesions also Tumor lesions cannot usually be differentiated from disk lesions by physical signs In 8 per cent of the tumor cases neurological signs were not present

The myelogram is the most significant and valuable aid in the differential diagnosis They prefer the use of pantopaque, removed at the time of fluoroscopy

Estimations of total protein ranged from 14 to 610 milligrams per 100 cubic centimeters the average being 140 A protein determination of over 100, definitely suggests tumor and is a valuable diagnostic aid However, in 30 per cent of the patients who had tumors the total protein was not elevated

In their series, 20 per cent of the tumors were malignant Of the benign tumors, neurilemmoma was by far the most common, with ependymoma second

Part III

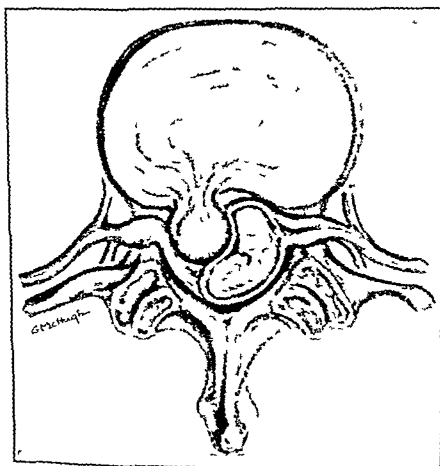
INTERVERTEBRAL DISK SYNDROMES

INTRODUCTION

"No discovery is ever made by one man or group of men. Had it not been for the reports of the various workers in neurosurgery, in pathology, in neurology and in orthopedics, the focusing of attention on rupture of the intervertebral disk and its importance as a clinical entity would have been impossible." (Mixter)

In a book by Charles Bell, written in 1824, there is an illustration which is the first portrayal of a ruptured intervertebral disk.

In 1896, Kocher wrote about a man who fell 100 feet, landing on his feet. Autopsy showed that his first lumbar disk had been shattered and squeezed out from between the vertebrae into the spinal canal.



B

FIG 323.—*A* and *B* Ruptured intervertebral disk in relation to spinal nerves. (From an article by F. B. Schlesinger and F. E. Stinchfield in J. Bone & Joint Surgery 33 A 480, April 1951. Published in *What's New* #161, p. 12, Abbott Laboratories.)



Fig 323 *A*

Part III

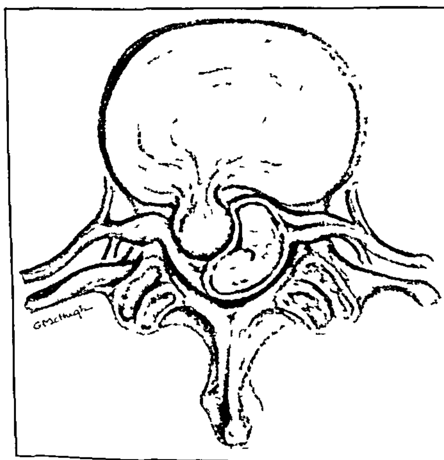
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Fig 323 A

exploration of the whole lower cauda equina, a small mass was found pressing backward against the first sacral nerve root and arising from the fifth lumbar disk. It was incised and the rolled up cartilage removed piecemeal, allowing it to collapse, thus relieving all pressure on the root.

Dr Kubik's diagnosis was enchondroma. Dr Barr had been struck by the fact that the patient had a dual syndrome, namely, a derangement of the lower part of the back and an accompanying sciatica. A day or two after the operation Drs Barr and Mixter met in the hospital corridor and stopped to discuss the case. Barr stated that the symptoms had followed an injury and therefore the diagnosis of tumor was unsound. It was recalled that Dr Kubik had stated that the microscopic sections in a similar case appeared to be normal cartilage. Barr suggested that the lesion found in the patient's spine might be a Schmorl nodule. Barr examined the slides and was struck with the lack of cellular material in the specimen. He obtained some material from normal disks, had sections prepared and compared them with the specimen from this patient. The two tissues seemed to him and to Dr Kubik to be identical, thus confirming the idea that the lesion was not a neoplasm.

The first step was to review the pathologic specimens of all the patients with "enchondroma" of the spine operated on at the Massachusetts General Hospital. Six of the lesions were undoubted enchondromas or were unclassified. The remaining 10 proved to be normal cartilage. Here was a considerable group of lesions previously described as neoplasm but undoubtedly of traumatic origin. A review was made of the records of these cases for clinical evidence, keeping in mind particularly the dual syndrome of low back derangement and sciatica in those cases in which the lesion was in the lumbar region.

During the next eight months 7 patients were operated on. On December 19, 1932, six months after the operation on K. N., Mixter operated on L. C. with a preoperative diagnosis of ruptured intervertebral disk, and found the lesion. In 1933 sufficient material warranted publication. The first paper was read before the New England Surgical Society on September 30, 1933, and published in the New England Journal of Medicine, August 2, 1934. Dr Barr previously had read a paper in the spring of 1933 before the Peter Bent Brigham Hospital Alumni Reunion.

After the reading of the paper September 30, 1933, but before its publication in 1934, Mauric's monograph on the intervertebral disk came to Mixter's attention. Mauric's conclusions, based in the main on an exhaustive and critical study of the literature, were similar to those of Barr and Mixter.

Mixter found the best way to convince a skeptical surgeon was to have him "scrub" with him and see and feel the protruded fragment for himself before it was removed. Dr James Love of the Mayo Clinic spent several days with Dr Mixter and returned to Rochester to review their cases of unexplained sciatica. Love's series is now larger than that of any other surgeon in the world.

In retrospect, it can be seen that the syndrome of the ruptured intervertebral disk lay for many years like the scattered pieces of a picture puzzle. All the pieces were in the literature and, more importantly, for Barr and

In 1907, Krause reported an enchondroma of the vertebral column compressing the cauda equina In 1909, Krause and Oppenheim wrote about a patient who had had attacks of low back pain for years He had been in a fight and his back had been injured Pain in the back and left leg ensued followed by pain in the other leg and gradually increasing paralysis of both legs, bladder and rectum At operation a tumor was found and removed It lay anterior to the anterior dura and opposite the second lumbar disk The drawing in their article strongly suggests a ruptured disk

In 1911, Goldthwait, Middleton and Teacher reported cases of severe injury to intervertebral disks with transverse lesions of the cauda equina

Goldthwait's patient had sciatica and paraplegia after a sacroiliac manipulation At operation, the dura was opened and narrowing of the sac at the level of the fifth lumbar disk was noted This was a case of a ruptured 5th lumbar disk During the next seventeen years no mention is found of isolated injury of intervertebral disks, but there are reports by Frazier, Elsberg, Stookey, Ott and Adson and others including Mixter, of "enchondromas" which are now known to have been ruptured disks During the latter part of this period came the studies of Schmorl and others

In 1929 Dandy reported 2 cases of transverse lesions of the cauda equina caused by free fragments of intervertebral disk tissue in the spinal canal In his summary he stated "This lesion offers a pathologic basis for cases of 'so called sciatica' especially bilateral sciatica"

Dandy's article did not attract the attention that it deserved No attempt was made to correlate the lesions in these cases with the enchondromas, and not enough evidence was brought forward to prove the connection of the lesion he described with chronic unilateral sciatica Nevertheless he was the first to report 2 cases in which there was surgical treatment for rupture of an intervertebral disk and the first to postulate that such fragments might be a cause of sciatica

In 1930 and 1931, Alajouanine and Petit-Dutaillis and Crouzon, Petit-Dutaillis and Christophe reported 2 similar cases, calling the lesion a fibrocartilaginous nodule Bucy reported 1 case and collected 15 others from the literature He spoke of 3 or more cases reported to him by Peet in a personal communication Bucy called the lesion an enchondroma

On July 30 1930, Dr Mixter operated on a person named F D Dr C S Kubik remarked "I suppose we must call this lesion a tumor as you found a mass projecting into the spinal canal The sections certainly look like normal cartilage" By this time Mixter recognized the characteristic appearance of these curious "enchondromas" and after that had differentiated them from enchondromas of bone

In June 1932 a patient was admitted to the Massachusetts General Hospital He was recommended to the hospital by Dr Frank Ober with the request that his case be studied by Dr J S Barr and Dr William J Mixter The patient had been hurt in a skiing accident The history and observations were identical with those of a ruptured intervertebral disk

Examination of the spinal fluid revealed no evidence of a dynamic block, but the total protein was 108 mg per hundred cubic centimeters In view of the fact that he was totally incapacitated and in pain, operation was advised The preoperative diagnosis was tumor of the cauda equina After

CHAPTER 11

THE SPINAL CANAL AND ITS NORMAL CONTENTS—SPACE-OCCUPYING LESIONS

HISTORICAL

INTERVERTEBRAL disks have been the object of study for several centuries. In 1555 Vesalius described the difference between the consistency of the annulus fibrosus and that of the nucleus pulposus. Virchow made further anatomical studies in 1857, and one year later von Luschka accurately described their structure and embryology.

Between 1855 and 1880 various writers made contributions to the embryology of the spine stressing the importance of the fetal notochord.

Kocher in 1896 recorded the first account of traumatic rupture and herniation of an intervertebral disk.

It is remarkable to see how precisely Goldthwait illustrated a posterior protrusion of an intervertebral disk.

Then came the observations of Adson, Dandy, Stookey, Middleton and Teacher, and several others.

In 1927 Schmorl began his meticulous exhaustive postmortem studies which revealed 38 per cent of displacements of the nuclei pulposi into the spongiosa of vertebral bodies. Schmorl and Andrae also called attention to the masses consisting of nucleus pulposus which had herniated through defects in the annulus fibrosus into the spinal canal. Schmorl recognized the frequency of protrusions but did not consider them of clinical significance.

Every medical student observed the anatomy of the disks but very few paid any attention to their physiology, biomechanics, pathologic changes, or their potentialities for causing clinically demonstrable trouble. Moreover, their instructors did not impress them, with the importance of these structures or their clinical application.

No one thought a disk could act as one jaw of a nutcracker to pinch a spinal nerve and produce a clinical syndrome that was amenable to treatment.

Very few clinicians were interested in what *could* happen to a disk or in what *does* happen to it during everyday life, such as: (1) degeneration, (2) protrusion, (3) extrusion, (4) pressure, (5) calcification, (6) infection, (7) relation to fractures and dislocations, and (8) importance in nearby malignancies.

For several years I asked myself the question "Where does a 'wandering disk' hide between attacks?" Dandy thought he explained it on the basis of a "concealed disk."

The Lord intended that the spinal canal should contain: (1) The spinal cord, (2) the spinal nerves, their roots, coverings, vessels, and ligaments, (3) spinal fluid, (4) blood vessels and (5) the dura.

Mixter, in the cases in their own clinic. Yet Barr and Mixter might never have completed this picture had they not met in a corridor that day to discuss at length the case of K. N.

Dr. Barr and Dr. Mixter both feel that every credit should be given to the long list of surgeons who faithfully reported their cases of "enchondromas," to those who reported the few cases recognized as rupture of the disk, to Schmorl and his co-workers for the discovery of Schmorl's nodules and especially to Dr. Walter Dandy, who was the first to hazard the opinion from the 2 cases which he reported that this lesion might be responsible for sciatica.

The subject of intervertebral disk lesions is unique. Many surgeons were "on the verge" of discovering the syndrome as a clinical entity.

In 1934 Mixter and Barr demonstrated that a protruded intervertebral disk could cause sciatica. This was a bombshell in the diagnostic and therapeutic arena of back, neck and extremity disorders. Very few, if any, concepts have equalled the widespread dissemination of knowledge in so short a period, as the disk syndrome.

We have been accumulating a great deal of valuable data on a subject that occupies an important place in everyday medical practice. Disk operations have increased in numbers in twenty years from a rare occasion to a daily occurrence in most hospitals throughout the country.

Responsibility for the future of this subject rests with the neurologists, neurosurgeons, roentgenologists and orthopedic surgeons. Repeated discussions of experience and exchange of ideas will produce the answer to most of the questions posed by disorders of the disks. One of the most important points, is acquainting the general practitioner with the value of early diagnosis and treatment.

The disk syndrome confused the study of back disorders, at first, but the recognition of its role in the over-all picture of back derangements with or without sciatica, has had a very helpful effect on diagnosis, treatment and prognosis. There are still some "doubting Thomases," but "Seeing is Believing." We must not, however, allow the pendulum to swing too far, nor too fast.

Space occupying lesions of the spinal canal are among the most important of all back and neck disorders, whether spinal nerves are affected or not.

The chief lesions are protruded intervertebral disks and spinal cord tumors.

The following lesions *can* occupy space in the spinal canal: a protruding disk, a protruded disk, a spinal cord tumor, a vertebral tumor, any disease exudate, an aneurysm, an exostosis or spur, and rupture of a spinal artery or vein.

Pain from space-occupying lesions in the spinal canal results from either traction or pressure on, or tension within, one or more spinal nerves or their roots.

The structures of the back and their workings are as intricate as those of a Swiss watch. The watchmaker or repairman has to remove the crystal and the works to determine what is wrong. The physician however must diagnose the trouble before he removes anything. He may prescribe rest and medicine for pain but he must make an accurate tentative diagnosis without the removal of anything but the patient's clothing.

In an historical review, Love found that in 1857 Virchow referred to a traumatic extrusion of cartilage from an intervertebral disk. However, it was not until March 1911 that Goldthwait directed the attention of the medical profession to the importance of intraspinal extrusion of disk tissue with compression of the cauda equina. In July of that same year there appeared an article by Middleton and Teacher in which they described a case of injury of the spinal cord caused by rupture of an intervertebral disk during muscular effort. Their patient died and the results of a post-mortem examination were recorded. They were able experimentally to

The spinal canal was considered sacred, but in the year 1911 it was hunted, it was not, and 1934 proved that its integrity had often been threatened and that it was destined to be violated more and more often

The Lord reserved the spinal canal for nerves, fluid and blood vessels, He did not leave much reserve "parking space" Two objects cannot occupy the same space at the same time without causing pressure on one or both When any structure encroaches on these normal "occupants," one is dealing with a space occupying lesion of the spinal canal This situation will usually demand surgical relief sooner or later

If you insert your thumb in a vice and some one turns the screw to the limit, the pain is like that of sciatica However, if he gives it one more complete turn that pain is like that caused by a protruded disk A nutcracker must have two "jaws" to exert pressure

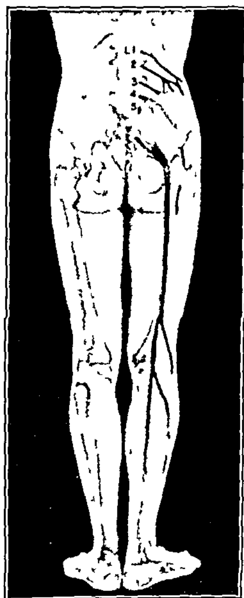


Fig 324 —Course distribution and anatomical relations of the sciatic nerve (Barr courtesy of Jour Bone & Jt Surg)

By close cooperation between neurosurgeons and orthopedic surgeons a new chapter in the etiological diagnosis of sciatic pain has been written. In 1934 Mixter and Barr demonstrated that root compression as a result of pathological changes in the intervertebral disk was a common cause of severe sciatic pain. In addition they called attention to the true nature of the "chondromas" and the role played by the nucleus pulposus in these lesions. Prior to this important contribution, the diagnosis of ruptured intervertebral disk could only be made at operation. Moreover the lesion was usually mistaken for a neoplasm. Spines were explored only when the symptoms and findings were those of spinal cord tumor. Mixter and Barr deserve the credit for calling attention to the presence of ruptured disks

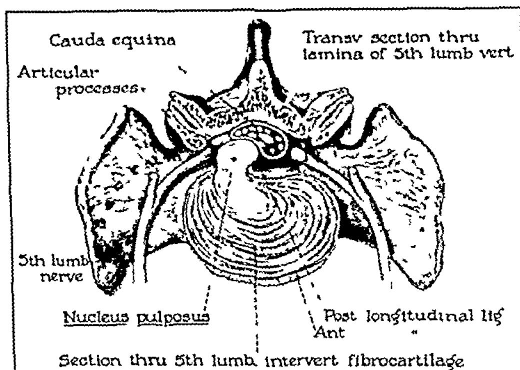


Fig 326 —Relation of a ruptured nucleus pulposis to spinal nerve (Magnuson courtesy of Ann Surg)

in many cases of severe back and sciatic pain with but meager neurological findings. This new syndrome was discovered through the integration of the knowledge accumulated by several investigators. Dandy claims that intervertebral disk protrusion has become the most frequent lesion encountered by neurosurgeons.

Mixter localized the lesion before the protruding disk had produced a total block in the spinal canal. Pantopaque may become permanently deposited in the subarachnoid space (unless removed subsequently) and pass freely into the fluid-containing spaces in the cranial chamber. It is a matter of concern even though there is no absolute proof that it does actual harm. Its presence is a good pretext for medico legal action particularly if no disk is found at operation.

reproduce the lesion in another spinal column In 1922, Adson removed a protruded lumbar disk from the spinal canal of a dentist suffering from intractable sciatic pain That patient was cured In the same year, Adson removed a portion of a protruded cervical disk, a report of which he included in a paper on tumors of the spinal cord, published in July 1925

In 1928, Stookey reported a series of 7 cases of protruded cervical intervertebral disks Dandy, in 1929, reported 2 cases of paraplegia caused by protrusions of lumbar disks and discussed the role of trauma in the causation of these lesions Mixter and Barr in 1934 reported a series of cases and emphasized the value of radiopaque oil as a contrast medium within the subarachnoid space, in the detection of these lesions They forged the important link connecting an anatomical or pathological curiosity and a clinical syndrome curable in the majority of cases by surgery

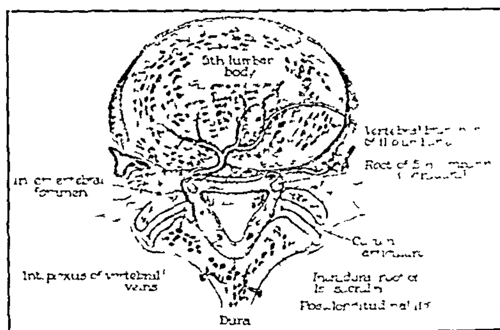


Fig 325 —Blood supply to intervertebral disk (Magnuson courtesy of Ann Surg)

In 1936 Love introduced the title 'Protrusions of the Intervertebral Disk (Fibrocartilage) In 1937 Capener reported a typical case of lumbar disk protrusion with cure following laminectomy

Intraspinal protrusion of intervertebral disks accounts for many cases of hitherto unexplained intractable pain

In discussing Dr Mixter s paper presented at the American Medical Association Convention in 1948 I remarked that many men had been "nibbling at this problem but they did not know exactly what they were nibbling at Mixter Barr and Kubik deserve the credit for connecting all the links in the chain Further study observation and collaboration between the neurosurgeon and the orthopedic surgeon will teach the general practitioner and help to clarify the problems presented by disturbances of intervertebral disks

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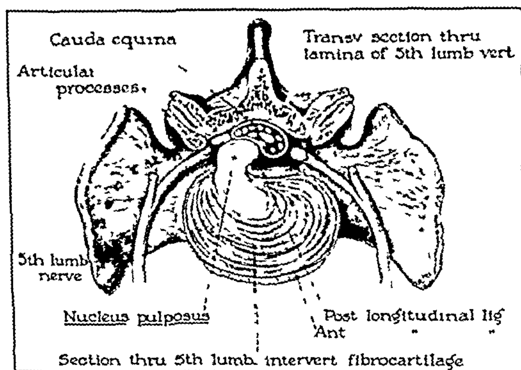


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In 1937 Reichert first substituted air for iodized oil as a contrast medium and in 1939 reported 35 cases with excellent diagnostic results. Air shadows are by no means as striking as iodized oil shadows.

The next diagnostic advance was made by Semmes who reported 16 cases that were diagnosed solely by history and neurological examinations without benefit of any contrast medium.

The modern concept of the syndrome of protrusion of intervertebral disk dates from the work of Dandy, Adson, Mixter and Barr, Love, Craig, Camp, Walsh, and Bradford and Spurling. Since 1934 a voluminous literature on the subject has accumulated. Saunders and Inman presented an excellent review of the early literature.

The first published report of a patient operated on for protrusion of an intervertebral disk into the spinal canal was that of Oppenheim and Krause in 1909. Their patient had a complete transverse lesion of the cauda equina at the level of the 3d lumbar disk. The protruded portion was removed at operation and the patient recovered. Adson performed his first operation for this lesion in 1922. Numerous reports of "enchondromas" appeared between 1911 and 1929. In the latter year Dandy reported 2 lumbar cases and recognized the distinct character of the lesion, comparing the extruded portion of the disk to the free fragments found in the knee joint. Peet and Echols also recognized the lesion about the same time. All these earlier reports had to do with cases with symptoms indicating transverse lesions of the spinal cord.

Mixter and Barr's interest was aroused in 1932 by the case of a young man with severe intractable sciatica following a fall. Although neurological signs were absent, the patient had a definite protrusion causing compression of the 5th lumbar nerve root. When they reviewed their cases they found that about 75 per cent of their enchondromas were not tumors but were protrusions of normal disk cartilages. In 1934, they called attention to the fact that unilateral leg pain was the outstanding symptom of a protruded disk. It is remarkable how close many surgeons came to the discovery of the disk syndrome. This is especially true of Putti, Adson, Dandy, Bucy, Goldthwait, Ghormley, and others.

Schmorl who dissected more than 10,000 cadavers found only 2 cases of traumatic rupture of a nucleus pulposus. He found various degrees of degeneration of disks and ligaments in more than 15 per cent of all subjects.

The disk syndrome is a definite clinical entity that is amenable to accurate diagnosis, differentiation, localization, conservative treatment or surgery and cure.

Some of the questions to be solved are:

1. What causes a disk to prolapse?
2. Then, what causes the pain?
3. Explanation of remissions of symptoms?
4. Is a positive diagnosis possible?
5. Is precise localization possible?
6. What should be done?
7. Is surgery advisable?
8. To fuse or not to fuse?

The suggestion that a small bit of normal or near normal disk tissue could, by impingement on a nerve root in the spinal canal, cause low back and sciatic pain was made according to Barr, by Goldthwait forty years ago. The first report of a series of cases treated by surgical excision of protruded disk tissue was made twenty-three years later. Since 1934 the literature on the subject has become so voluminous that the reader may easily become baffled and bewildered.

Schmorl, in 1930, demonstrated posterior protrusion of intervertebral disks in 15 per cent of 8000 subjects. He did not, however, attach much clinical significance to it. Beadle and Andrae and others confirmed Schmorl's findings and thought the pathologic changes might be of clinical significance.

In 1930 Galland and Calve presented several papers on the subject. These were excellent. However, they did not realize the great import of their observations from the standpoints of etiology, clinical diagnosis and treatment. Mixter and Barr and Kubic established the clinical and anatomical causal relation of a disk lesion to sciatic pain.

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and thus change the mechanical situation of a given disk This leads to deformations and tension disturbances

NERVE SUPPLY TO THE DISKS

Luschka in 1858, demonstrated that a special nerve which arose just distal to the spinal ganglion, joined a sympathetic branch and passed into the spinal canal, where it split up into branches He called it the sinu-vertebral nerve

Hovelaque like Luschka, believes that the sinu-vertebral nerve is formed by a cerebrospinal and a sympathetic root, although there may be two roots of the same type The roots either unite early, so that a single stem passes through the intervertebral foramen, or later, within the spinal canal The common stem, when well inside the canal, breaks up into branches, which end as fine fibers in the dura, the outer surface of the vertebral bodies, the ligaments and the vessels

Steindler believes that the sensory innervation of the posterior portion of the spinal column is furnished largely by the sinuvertebral nerve This nerve is a recurrent branch of a spinal nerve coming off just distally to the ganglion of a posterior root As it separates from the main trunk, it reaches a vertebral foramen and supplies all ligamentous structures, the capsular apparatus a section of the posterior longitudinal ligament, and the periosteum It is said to contain sympathetic postganglionic fibers for the blood vessels

Jung and Brunschwig found that the disk contained no nerve tissue, but that there were nerves in the surrounding fibrous ligaments

Wiberg agrees with Spurling and Grantham that palpation of an intervertebral disk causes back pain Either the recurrent nerve branch supplies the intervertebral disk two vertebrae lower, or the recurrent branch from the opposite side transmits the pain

The clinical observations of Falconer, McGeorge and Begg indicate that low back pain is caused by disk prolapse alone, presumably through involvement of the sinuvertebral nerve and that sciatica occurs only when the prolapse is so situated that it impinges upon a nerve root in its extrathecal course at the level of either of the lower two lumbar disks Secondary changes probably of intraneural edema appear within the affected nerve root, which contribute to the production of symptoms by pulling the nerve root tightly against the disk prolapse thereby causing angulation and other strains within it These strains excite afferent impulses within the nerve which on reaching the sensorium, produce a sensation of pain referable to the peripheral distribution of the affected nerve root A slight block in conductivity through the compressed segment of nerve root accounts for the associated muscular sensory and reflex disturbances Falconer and his associates believe the spontaneous remission of symptoms which often occurs in sciatica can result from a resolution of the neural changes without an associated change in the disk prolapse

The lesions occur as the result of a tear in the annulus fibrosus, and a rupture of an intervertebral disk with expulsion of a portion or all of its nucleus pulposus

CHAPTER 45

THE ANATOMY OF AN INTERVERTEBRAL DISK

Hirsch describes the intervertebral disks as made up of three types of tissue Plates, consisting of hyaline cartilage, separate them from the vertebral bodies A solid elastic ring, the annulus fibrosus, forms the main mass of the disk and encloses a somewhat eccentrically situated plastic

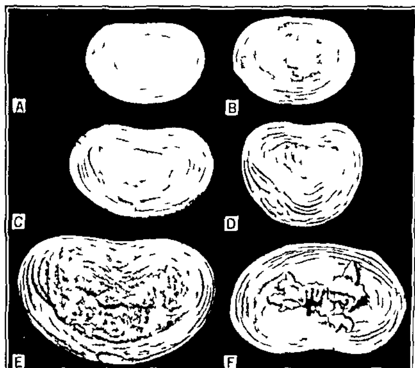


Fig 327 —*A* Horizontal section of an intervertebral disk of an infant *B* Horizontal *section of a disk of an adolescent C Disk in the fifth decade showing fibrous transformation* *D* Disk in the sixth decade showing fibrocartilaginous transformation *E* Disk in the eighth decade showing gross cartilaginous and necrotic changes *F* Horizontal section (dissected) of an intervertebral disk showing its synovial like cavity (Luschka) (Ross)

substance the nucleus pulposus a watery gel composed of a dense collagen structure permeated with polysaccharides, containing chondroitin sulphuric acid

The disk is covered dorsally and ventrally by the anterior and posterior longitudinal ligaments In the adult an intervertebral disk has no vessels There is an abundance of nerve ends in the posterior ligament whereas the disk itself is without sensitive end organs although these possibly occur in the posterior external parts of the annulus fibrosus Internal derangements of the structure of an intervertebral disk produce variable pressure conditions

According to Delitala, this accounts for the high incidence of herniated disks in the lumbar area. The nucleus pulposus may suffer deformation but cannot be compressed because of its high content of fluid. One may consider a small cushion of water, a liquid medium adapting itself passively to the pressure of the annulus fibrosus which is elastic. When one passes from the horizontal to the vertical position, the nucleus pulposus is subjected to a pressure of 45 Kg. When one passes from flexion to extension of the spinal column, the nucleus must sustain a pressure of 90 to 127 Kg. One can imagine the pressure exerted when one lifts heavy objects. Delitala exerted mechanical pressure of 500 Kg. on portions of the vertebral column which had been removed from cadavers, an amount which approaches that to which the vertebral column is subjected when one lifts a heavy stone. He observed that a herniated disk always protruded according to the mechanism of an incompressible cushion, which breaks the annulus fibrosus.

Paradiskal Defects in the Anterior Portion of the Vertebral Body.—If one assumes that impaction of disk tissue is responsible both for the anterior paradiskal defects and the persisting apophyses, Hellstadius believes that all the facts can be correlated. In that case "Knorpelknotchen" as well as anterior paradiskal defects and persisting apophyses, would arise in the same manner, *i.e.*, either from an isolated trauma or from a gradual progression of the impact of disk tissue into the cancellous bone of the vertebral body. In the case of "Knorpelknotchen" the disk tissue is derived from the nucleus pulposus, whereas anterior paradiskal defects and persisting apophyses, originate from the portion of the annulus fibrosus situated in front of the nucleus.

Some cases are described with roentgenograms, showing defects within the anterior portion of the vertebral body adjacent to the intervertebral disk. The changes are probably due to a traumatic or gradually-developing impact of disk tissue situated in front of the nucleus pulposus, into the cancellous bone of the vertebral body.

The involved spinal root is compressed between the protruded portion of the nucleus pulposus and the pedicle of the vertebræ at the level of the intervertebral foramen

The annulus is first to suffer damage, especially in sedentary persons and in those who have senescent changes in the interspace Dual rupture at interspaces L-4-5 and L-5 S-1 are of more frequent occurrence than is generally recognized

When there are only four lumbar vertebræ the fourth interspace is more vulnerable, since it occupies the relative position of the normal fifth vertebra When there are six lumbar vertebræ, there is less likelihood of extrusion at the fourth interspace as the fourth lumbar is much higher and participates less in the ligamentous connections with the ilium and sacrum

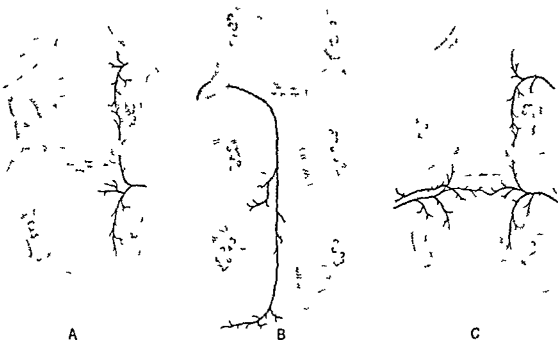


Fig 328 – The course and division of the recurrent nerve (sinu vertebral nerve) according to (A) Luschka (B) Roofe (C) Wiberg (Wiberg courtesy of Acta Orthopaedica)

The fifth lumbar and first sacral roots are both vulnerable from a large extrusion at either the fourth or fifth interspace

Edema of the Disks —*It has been stated that the nucleus pulposus can absorb 16 times its own weight of water*

Delitala and Bonola studied the mechanism by which protrusion of the herniated disk could be determined experimentally under pressure They call attention to the fact that the nucleus pulposus is not situated in the center of the fibrous ring of the intervertebral disk but is somewhat eccentrically placed in the posterior space That applies particularly to the lumbar section of the vertebral column At the same time the portion of the fibrous ring which is situated in front of the nucleus is more dense than the portion of the fibrous ring which is situated in the posterior area

Intrinsic disk lesions include traumatic, degenerative and infectious conditions which have been described by Ghormley. In a typical clinical case of ruptured disk a large part of the mass is composed of nucleus pulposus. The presence of portions of the annulus fibrosus in this mass does not alter the fact that the presence of nucleus pulposus is the cardinal observation. Bradford and Spurling refer to this entity as "rupture of the annulus fibrosus with posterolateral or posterior herniation of the nucleus pulposus." Other terms used are "rupture of the intervertebral disk" and "herniation of the nucleus pulposus."

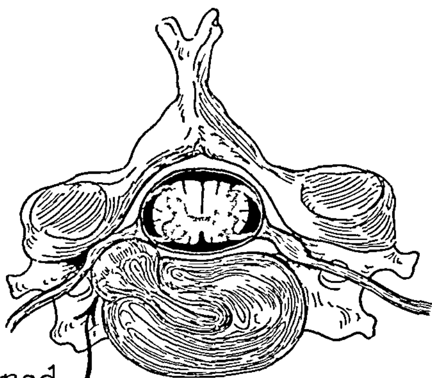


Fig 330 —Nerve root compression by a ruptured intervertebral disk is shown. On the opposite side the normal relationship of the nerve root is illustrated. (Redrawn from Spurling in Walker, Moore and Simpson, courtesy of Jour Int Coll Surgeons.)

Large ossifications protruding into the vertebral canal may be seen in the lateral roentgenograms as posterior spurs. Schmorl's nodules (herniated disk tissue) originate in the intervertebral disks. In addition, ossifications of the ligamenta flava or marginal dents of the smaller vertebral joints may protrude from behind into the vertebral canal. Friberg believes that disk degeneration occurs more often than disk rupture.

Due to the investigations of Goldthwait *et al*, and of Ghormley, Danforth and Wilson, attention was drawn to the anatomy and pathology of the vertebrae and the lumbar intervertebral articulation. Wahren recalls that the intervertebral disk was for a long time the only organ of the human body to which no clinical importance was ascribed.

CHAPTER 46

PATHOLOGICAL CHANGES IN DISKS

The chief pathological changes that involve intervertebral disks are (1) Degeneration, (2) protrusion, (3) extrusion, (4) calcification, (5) infection, (6) neoplasm

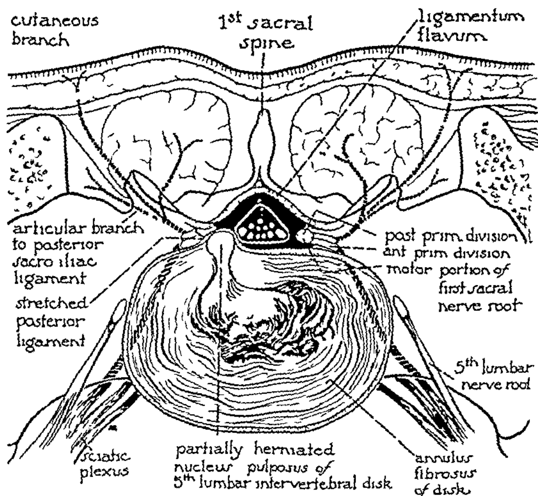


Fig. 329 With sufficient herniation of the nucleus pulposis through torn annular tissue compression of a nerve root results (Keegan J Jay courtesy of J A M A 120 868)

There are two types of disk lesions One is the classic prolapsed disk with compression of a nerve root pain in the back and radiating down the leg The other is degeneration of the disk Degeneration may be due to age, wear and tear or trauma Calcification of disks and their nuclei have been reported by Mantovani, Laserre and Phelippot and others

The relative avascularity of the intervertebral disk is a factor in the production of degenerative changes. The nature of the meager vascular supply is controversial. Defects left in the cartilage plates of the vertebral bodies by atrophied pre-pubertal blood vessels may explain the formation of Schmorl's nodules. Lumbar Schmorl's nodules have been reported in from 9 to 20 per cent of cadavers. "Brown degeneration" has been described in the intervertebral disks. "Fissuring" is found in senile disks.

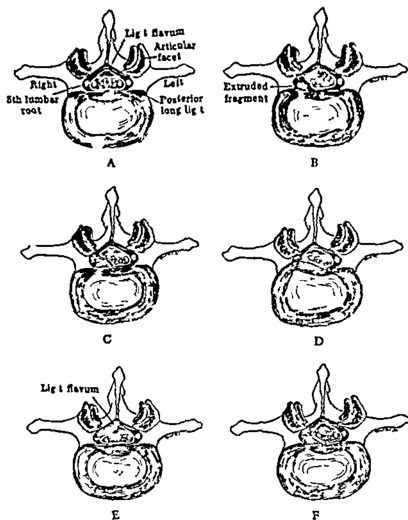


FIG 332 —The lumbar intervertebral disk and the ligamentum flavum. *A* represents a section through a normal fourth lumbar disk. *B* a free fragment of the disk with compression of the fifth lumbar root. *C* a free fragment with lateral displacement of the fifth lumbar root. D generalized posterior bulging of the disk. *E* a thickening of the ligamentum flavum. *F* a thickened ligamentum flavum with an extended fragment of the disk. (Mixter and Barr, courtesy of New England J Med 1942.)

The spinal columns of 40 cadavers were dissected, with attention concentrated on the cervical region.

Brown degeneration of the intervertebral disks was observed in 28 specimens (70 per cent) and was not closely correlated with other degenerative changes.

Fissuring of the intervertebral disks was observed in 30 per cent of the specimens.

This, however, was radically changed by the investigations of Schmorl and Junghans, and above all by Mixter and Barr's brilliant conception of the herniated nucleus pulposus. This has drawn attention away from the far more common degeneration of the disk.

Degeneration of a disk, especially in the most flexible portion of the back, the lumbar region, is undoubtedly the main cause of chronic and recurring back pain. There are also other causes. Spondylolisthesis and unilateral sacralization of the 5th lumbar disk may be associated with back symptoms. In both of these affections there are concurrent disk changes.

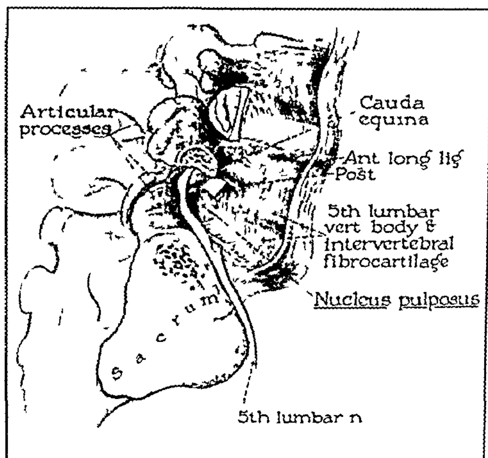


Fig. 331.—Pathological anatomy of ruptured disk and spinal nerve. (Magnuson, courtesy of Ann. Surg.)

Since the work of Schmorl in 1927 there has been growing interest in the study of the various degenerative changes associated with the aging process in the spinal column, especially in the disks. In one of the most instructive reports of the investigation of the spines of 50 cadavers, Morton discusses the developmental anatomy of the vertebral column. The notochordal origin of the nucleus pulposus of the disk and the progressive decrease in its mucoid content during fetal life have been described. Progressive degenerative changes occur in the disks throughout life. From the eighteenth to the seventieth years the water content of the nucleus pulposus falls from about 80 per cent to between 70 and 75 per cent.

Hadley finds that a spur projecting from the lateral margin of the 5th lumbar disk may encroach on a nerve to the extent of distorting its shape and displacing it from its normal position. In the lumbar region the lumen of the spinal canal is relatively large. A rather large amount of disk substance or thickened ligamentum flavum must protrude into the canal before there is pressure against the nerve. Hernia into an intervertebral foramen

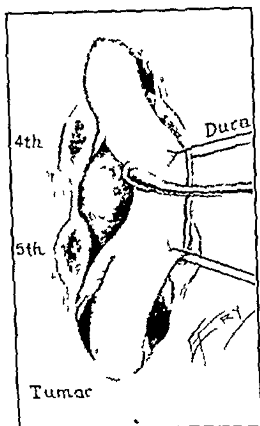


Fig. 334

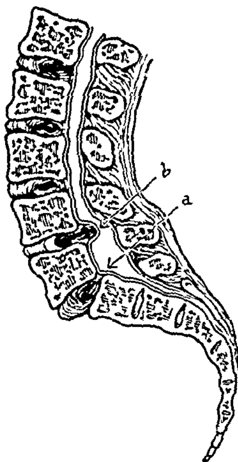


Fig. 335

Fig. 334.—Protruded fourth lumbar intervertebral disk producing bilateral sciatic pain. Removal of the protrusion resulted in complete relief of symptoms. (Love, Adson and Craig, courtesy of Arch. Neur. Psychiat.)

Fig. 335.—A disk lesion in association with *spondylolisthesis*. When a disk lesion exists in association with a spondylolisthesis the level of root irritation is not at the "step" or the anterior wall of the canal (*a*) but one segment above at the site of the abnormal disk. (*b*) Armstrong, Lumbar Disk Lesions, courtesy of E. & S. Livingstone Ltd.)

is an entirely different matter. In this situation, one has a bony ring which cannot expand. In a stained section of the fourth and fifth intervertebral foramina the fourth foramen shows the nerve root oval with ample room around it for blood vessels, areolar tissue, lymphatics and fibrous tissue. This is definite microscopic evidence of nerve root encroachment by a herniated disk. Hadley believes that herniation of disk substance into an intervertebral foramen is more important than bulging into the spinal canal.

Terminology.—The terms concealed, bulging, ruptured, herniating, protruded and slipped disk are sometimes erroneously used interchangeably

Posterior thinning was observed more frequently in the cervical and lumbar regions, accentuating the normal cervical and lumbar curvatures, whereas anterior thinning of the disks was more prominent in the thoracic region.

Degeneration of the disk may produce clinical manifestations. The destruction of the elastic pulposus portion must cause friction between the

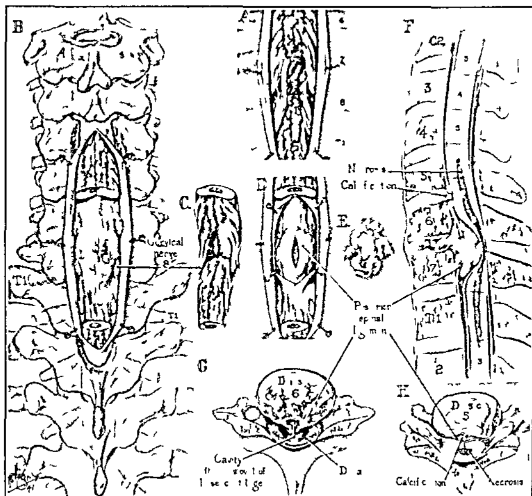


FIG 333 — A. The spinal cord with the necrotic interior beginning to protrude at the surface. *B.* Section of the cord removed to show the dura bulging because of rupture of the intervertebral disk. *C.* Drawing of the cord to show the effects of compression of the disk. *D* and *E.* Cartilage removed from the bulging disk. *F.* Diagram showing the effect of the lesion of the cord; note the extent of the necrosis of the interior of the cord. *G.* Transverse section of the affected disk showing the extent of the necrotic interior. *H.* Cross section of a normal disk for comparison with the affected disk (*G*). (Dandy, courtesy of J. A. M. A.)

surfaces of the vertebrae, which roentgenologically is manifested in the lateral projection as sclerosis of the vertebral borders. Wiberg by direct investigations at operation has shown that the disks and their ligamentous covering are pain perceptive. Degeneration of the elastic pulposus substance sometimes produces roentgenologically demonstrable instability between the vertebral bodies. Due to this instability, the central disk and its ligament may be subjected to abnormal and painful tensions. The nerve root situated in the intervertebral foramen may also be compressed

annulus fibrosus When the radiograph showed reduced disk space, sclerosis or osteophytes, the corresponding disk was severely damaged

In cases with prolapse of a disk, the structure had the same pathological characteristics as in cases of simple degeneration They concluded that prolapse is part of the phenomenon of degeneration of a disk

Radiographic disk degeneration was found in 39 per cent of all the patients who came to Friberg and Hirsch for "back trouble" and in 50 per cent of the material covering the last two years of their investigation Forty-three per cent of the cases with disk degeneration were women, and



Fig 337 —The lumbosacral intervertebral disk of a 34 year old man (× 4) Degenerative changes are especially evident in the nucleus pulposus and the annulus fibrosus A higher magnification of nuclear changes and fissuring were seen in the cartilaginous plate (Coventry courtesy of Iroc Mayo Clinic)

57 per cent, men Seventy-four per cent of the men were engaged in some kind of physical work They found no evidence that heavy physical work was the direct cause of the disk changes

They found that disk degeneration occurs most frequently (in 47 6 per cent) in the 4th lumbar disk and in 75 2 per cent in the 4th and 5th disks together In 15 per cent of the observations, instability was the only radiographic change In 70 3 per cent (of these) it occurred at the 4th disks

Their investigation indicates that radiography does not provide satisfactory information regarding the condition of the disk They find the instability test to be a valuable aid in diagnosis

The investigations of Friberg and Hirsch have shown the great frequency of degenerative changes in the lumbar intervertebral disks As early as the age of twenty years, manifest structural transmutations may be ob-

Lewey studied 169 disks removed at operation. He grouped the pathologic findings into three classes (1) the bulging disk without a rent in the annulus fibrosus and without detachment of the disk from the bone, (2) the herniated disk in which traumatized disk lamellae are protruded through a rent of the annulus fibrosus into the spinal cavity where they may encroach on and overextend a posterior root (3) The slipped disk in which the trauma involves the cartilaginous epiphyseal plate and which is sometimes accompanied by a chip fracture of the vertebral rim. This frees the disk from its anchorage and permits an eccentric portion of its posterior circumference to slip backward. A nerve root may become hooked up over the protrusion. The sharp bony edges of a fracture may rupture a slipped disk.

Rupture of an intervertebral disk and protrusion of its nucleus pulposus can occur at any spinal level. The most common sites are below the last two lumbar vertebrae. The next most common locations are below the

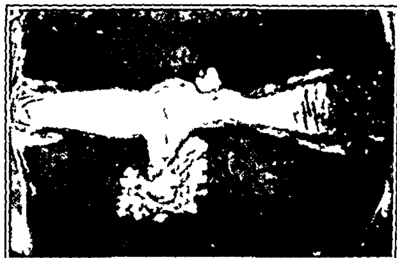


Fig. 336.—The mulberry like form of nuclear prolapse. This branched nodule consists of almost pure newly formed cartilage. (A Schmorl node.)

fifth and sixth cervical vertebrae. Protrusions of thoracic disks are either rare or are not being diagnosed.

Guntz described two types of disk lesions *viz* displacement of disk tissue through the annulus or cartilage plates and alteration in the composition and turgor of the nucleus. He believed that low back pain was due to arthritis of the posterior articulations rather than to nuclear hernias.

Postmortem material reveals that disk degeneration acquires pathological importance when the annulus fibrosus begins to rupture.

In the lower lumbar disks Friberg and Hirsch found that ruptures in the annulus were localized chiefly to the posterior part of the disk. From the center they were directed either sagittally or laterally backwards to the intervertebral foramen. In the upper disks the ruptures were frequently directed anteriorly. They found that marked degeneration may be present without any radiographic changes. Thus a normal radiograph does not exclude degeneration of a disk. In 16 out of 17 cases with instability there were extensive changes in the disk and ruptures in the posterior part of the

annulus fibrosus. When the radiograph showed reduced disk space, sclerosis or osteophytes the corresponding disk was severely damaged.

In cases with prolapse of a disk, the structure had the same pathological characteristics as in cases of simple degeneration. They concluded that prolapse is part of the phenomenon of degeneration of a disk.

Radiographic disk degeneration was found in 39 per cent of all the patients who came to Friberg and Hirsch for "back trouble" and in 50 per cent of the material covering the last two years of their investigation. Forty-three per cent of the cases with disk degeneration were women, and



Fig. 337 —The lumbosacral intervertebral disk of a 34 year old man (× 4). Degenerative changes are especially evident in the nucleus pulposus and the annulus fibrosus. A higher magnification of nuclear changes and fissuring were seen in the cartilaginous plate (Coventry courtesy of Proc. Mayo Clinic.)

57 per cent men. Seventy four per cent of the men were engaged in some kind of physical work. They found no evidence that heavy physical work was the direct cause of the disk changes.

They found that disk degeneration occurs most frequently (in 47.6 per cent) in the 4th lumbar disk and in 75.2 per cent in the 4th and 5th disks together. In 15 per cent of the observations instability was the only radiographic change. In 70.3 per cent (of these) it occurred at the 4th disks.

Their investigation indicates that radiography does not provide satisfactory information regarding the condition of the disk. They find the instability test to be a valuable aid in diagnosis.

The investigations of Friberg and Hirsch have shown the great frequency of degenerative changes in the lumbar intervertebral disks. As early as the age of twenty years manifest structural transmutations may be ob-

served in the nucleus pulposus in a stage which can be characterized as an initial necrosis of the tissue In none of the 500 histological specimens examined by Hirsch had any healing process been observed The disintegration of the nucleus is a progressive process

Hirsch has shown by puncturing the disks *in vivo,* that changes in the intradiskal pressures, in cases of rupture of the annulus, cause sensations of pain similar to those experienced by lumbago patients Hirsch has evidence supporting the view that lumbago is a functional disturbance in one or several disks primarily caused by such a change in the biological composition of the nucleus pulposus that its plasticity is modified, resulting in a rupture of the annulus fibrosus The whole disk then fails to function normally

DESTRUCTION OF INTERVERTEBRAL DISKS

Intervertebral disks are frequently injured In some cases the nucleus pulposus may be forced through its enveloping annulus fibrosus and into the substance of the body of the vertebra immediately above or below In milder cases tears in the wall of the annulus may lead to desiccation or absorption of the disk Calcification of the nucleus may occur usually after long-continued mild traumatism It is a frequent finding and often without significance

The disks are rapidly destroyed in cases of tuberculosis of the vertebra but on the other hand, they are quite resistant to malignant metastasis *This is one of the important facts in the differential diagnosis between* these two conditions

Structural Changes in Annulus Fibrosus —The invasion of the fibrocartilage of the annulus may be an attempt on the part of the body to strengthen and nourish a structure which has become weakened and degenerated

Granulation tissue in the intervertebral disk may be an important pathological basis for low-back pain Hirsch was unable to find any nerve fibers in the annulus The most common changes observable in the annulus are concentric cracks or cavities In a large number of cases chiefly at the ages between thirty and fifty Hirsch found radiating ruptures in the annulus Hirsch suggests the idea that the appearance of a highly vascular granulation tissue within the intervertebral disk may constitute a new pathological basis for low-back pain He prefers the term annulus lamellosus

VENTRAL EXTRADURAL CHONDROMAS

Formerly small localized masses extending into the ventral part of the spinal canal opposite the intervertebral disks were considered true neoplasms and were designated by various terms as chondroma enchondroma ecchondrosis fibroma and fibrochondroma These masses represent extrusions of the nucleus pulposus of the intervertebral disk The earliest cases were reported as spinal cord tumors Steinke in a series of 330 spinal tumors collected from the literature and from Fraser's unpublished cases prior to May 1915 found 6 cases of cervical, thoracic and

lumbosacral enchondroma. A case of chondroma was reported by Clymer, Mixter and Mella.

Two "chondromas" of the lumbar intervertebral disks were reported by Ott and Adson (1923). In 1928 Elsberg reported 11 "chondromas" involving intervertebral disks and Stookey reported 7 cases, all cervical. Alajouanine and Petit-Dutaillis recognized that these "chondromas" consisted of the displaced nuclei pulposi of the intervertebral disks. The report by Elsberg of 15 patients with "chondromas" proves the similarity between certain parts of the intact intervertebral disk and the "chondroma." The lesions, even when sufficiently advanced to simulate neoplasms, are not rare, since 11 occurred in Elsberg's second series of 100 spinal cord tumors.

Ever since Dexler's work in the 1890's, a disease in dogs has been known by the name of "enchondrosis intervertebralis."

Hansen finds that the ventral extradural formations are signs of a disk prolapse. He draws a parallel between these intraspinal processes in both human beings and dogs, and their development in "disk degeneration" and "disk prolapse."

Lindblom and Hultquist call attention to the fact that intervertebral disk tissue may disappear spontaneously. A lumbar disk may decrease in volume from about 1.5 cc. to 1 cc. It is obvious that the disk tissue is "digested" and absorbed as it reaches the disk surface.

Fibrosis with vascularization of ruptured disks is a well known phenomenon. Eckert and Decker found fibroblastic proliferation and vascularization of the nucleus pulposus in about 25 per cent of their cases. Coventry, Ghormley and Kernohan found many tears in the annulus, though most of them were old, as evidenced by the amount of repair which had taken place in the nature of invasion of blood vessels and fibrous tissue.

The ingrowth of granulation tissue is a sign of repair or restitution. When considered in relation to the microscopic picture of disk degeneration in its different stages, it is reasonable to consider the cellular and vascular ingrowth as a sign of absorption. The disk is not replaced by invading tissue; it is "eaten." As a result, the prolapse as well as its resulting symptoms may disappear. The cellular and vascular reactions lead to fibrosis in the neighborhood of the disks, the longitudinal ligament, the dura, nerve roots, ganglion, and spinal nerve.

The local pathological condition of the affected nerve root is subject to change. The factors of inflammatory reaction are present in variable amounts and of variable duration,—as edema, blood-vessel engorgement, cellular infiltration, and intraneural or perineural fibrosis. Barr believes that individual nerve fibers which have been affected by a disk lesion may recover completely, or they may undergo axonal degeneration with loss of ability to respond to stimuli.

The local alterations in the bony structures of the vertebrae associated with a ruptured intervertebral disk are listed by Cloward as follows: (1) narrowing or reduction in the width of the normal intervertebral space, (2) narrowing or decrease in size of the intervertebral foramen, (3) changes in the articular facets, (4) sclerosis of the subarticular regions of the vertebral bodies, (5) "arthritic" spur formation, general or local, and (6) malalignment of the vertebrae.

CALCIFIED INTERVERTEBRAL DISKS—CALCIFICATION OF THE NUCLEUS PULPOSUS

Calcification of a nucleus pulposus was described first by Calve and Galland in 1922 An Englishman called it calcinosis intervertebralis, which means deposition of calcium in the gelatinous nucleus pulposus of an intervertebral disk The condition may produce symptoms of spondylitis or radiculitis The nucleus pulposus is not visible in the roentgenogram unless it is calcified when it appears as a lenticular opaque shadow with a granular aspect and of irregular thickness Situated in the posterior portion of the intervertebral disk it is clearly differentiated from the surfaces of the vertebral bodies

Calvé described 2 patients with calcinosis intervertebralis Both were thought to have spondylitis The symptoms in such cases are those of irritation of spinal nerve roots and meninges Calve attributes the condition to inflammation followed by the precipitation of calcium salts in the nuclei In the majority of cases the progress of the lesion stops in the stage of swelling and is often the cause of radiculitis even when the roentgenogram does not show calcification The inflammation may have occurred long before the development of the nerve root and meningeal signs and before the roentgen examination is made

Guilani reported 2 cases of spondylitis with calcification of the nucleus pulposus Differentiation is made between calcification of the annulus and the nucleus pulposus Most patients give a history of tuberculosis typhoid spondylitis or injury Calcification may occur in any of the three different tissues of the intervertebral disk They are (1) a thin covering cartilaginous plate demarcating above and below (2) the peripheral part of the ring-shaped annulus fibrosus and (3) the central nucleus pulposus Metastatic calcification is due to supersaturation of the colloid solution which makes up the fluids Dystrophic calcification is a local phenomenon which seems to occur only in dead tissue

According to Nicotra the condition is a localized infectious intervertebral chondroneuritis belonging in the same classification as infectious intervertebral spondylo-arthritis with the radicular syndrome Suggested causes are traumatism and a disturbance in the development of embryonic elements of the thoracic spinal cord The resorption of the calcification observed by Nicotra the presence of fever and the variable age of the patients suggest that the lesion is infectious especially since the pains of the radicular type the paresthesia and the muscular weakness which are all part of the syndrome indicate a change in the spinal nerves not satisfactorily explained by the discovery of calcification in the nucleus pulposus

Intercalary Bones (Oppenheim) —The intercalary bones of the intervertebral disks are described by Lyons as irregularly shaped isolated osseous formations interposed between two vertebrae and usually found in the anterior peripheral portion of the intervertebral disk They are found most commonly in the disks of the lumbar portion although they are occasionally encountered in the thoracic and cervical portions of the spinal column

On roentgenographic examination, the postero-anterior view reveals irregularly outlined shadows in the intervertebral space, in the neighborhood of the vertebral corner The lateral view shows them as homogeneous, triangular shadows, the size of a rice kernel or larger, situated in the anterior portion of the intervertebral space between the upper and lower edges of two adjacent bodies

These formations provide a rare accidental finding of secondary importance They represent the ultimate stage of a process in a lesion of the outer portion of an intervertebral disk and its nucleus pulposus

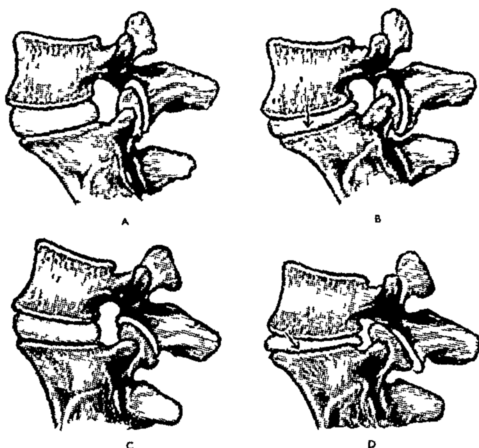


Fig. 338 —Relation between planes of posterior articular facets and intervertebral narrowing When the planes of the posterior articular facets are comparatively vertical *A* intervertebral narrowing is not associated with any great posterior shift of the fifth lumbar body in relation to the sacrum *B* When the planes are oblique however *C* narrowing of the L 5-S 1 space is accompanied by some backward displacement of the fifth lumbar body *D* (Armstrong Lumbar Disk Lesions courtesy of E & S Livingstone Ltd)

NARROWING OF AN INTERVERTEBRAL SPACE

In order to understand the cause of this condition Cloward recalls the anatomy and physiology of the disk itself The disk is composed of three separate structures the nucleus pulposus the annulus fibrosus and the cartilaginous plates Each of these is composed of a distinctly different type of tissue The cartilaginous plate is hard hyaline cartilage and on one side is firmly adherent to and covers the articular surface of the vertebral body, on the other surface, the fibers of

the annulus fibrosus are attached. The annulus fibrosus, as the name implies, is composed of tough fiber of elastic connective tissue arranged in an annular or circular fashion around the central nucleus pulposus, much like the circular arrangement of the layers of an onion. The nucleus pulposus or core of a disk is a semigelatinous, liquid like substance in the center of the vertical diameter of the disk and located at the junction of the middle and posterior third of the intervertebral space. The nucleus pulposus is a remnant of the embryonic notochord. A vertical line drawn through the center of the nucleus will pass through the weight bearing axis of the spine.

Disks act like non-compressible struts to hold and to keep the vertebral bodies separated. The amount of positive pressure in an intact disk and the amount of vertical compression necessary to rupture a disk is surprising. As a result of trauma the disk may be ruptured or torn. The tear takes place in fibers of the annulus, most often in the posterior half of the disk. Since injuries usually occur with the spine in flexion, the posterior fibers of the annulus are put on a stretch and are therefore more susceptible to being torn. As soon as the annulus is ruptured, the liquid substance of the nucleus pulposus loses its spherical shape, the liquid diffuses through the torn fibers of the annulus and the non-compressible support between the vertebral bodies is lost.

Once an intervertebral disk is ruptured and the support of the nucleus pulposus is no longer present, the patient has, and will always have, a pathologic vertebral joint whether it is symptomatic or asymptomatic.

It is impossible for a ruptured disk to heal. Even if healing did occur it would do so by scar or connective tissue replacement of the nucleus which would be compressible. If the patient is followed over a long enough period of time, the intervertebral space becomes progressively narrowed. In a 200 pound man in the upright position, the last disk of the vertebral column must support nearly 120 pounds of weight.

DECREASE IN SIZE OF AN INTERVERTEBRAL FORAMEN

This finding, presented in a report by Hadley, is a constant occurrence with ruptured disks. The most common cause of a narrowed foramen is herniation of a portion of the ruptured disk into the spinal canal. The second cause is an *encroachment by a slipping of the articular facet*. The changes which occur in the body of the vertebra resulting in so-called "arthritic spur" formation is the third cause of foramen narrowing.

CHANGES IN THE APOPHYSEAL JOINTS

The changes which occur in the apophyseal joints as a result of loss of the intervertebral (disk) support consist of slipping, degeneration of the cartilage, sclerosis of the bone and secondary bony proliferations or lipping. The slipping of the facet with weight-bearing results in narrowing of the intervertebral foramen with resultant pain. *Tension or traction* on the fibrous capsule of

the facet caused by slipping may also account for some of the patient's pain. Electrical stimulation of the joint capsule, at operation using local anesthesia, has shown this structure to be most sensitive and painful. The false motion set up in the apophyseal joint as a result of loss of the supporting function of the disk brings about changes seen in all weight bearing joints according to Wolf's law. With injury to the joint surfaces followed by excessive movement, an increased density develops in the underlying bone and the edges of the bony surfaces subjected to most trauma become worn down. An excessive proliferation of bone in response to the irritation develops. The thickening and lipping of the edges of the facets are readily visualized on the oblique *x*-ray.

Cloward has not found these changes in his *x*-rays of ruptured disks in which the interspace is still approximately normal in width. It has been a constant finding, however, that the narrower the interspace, the more dense and wide is the layer of sclerotic bone in the adjacent vertebral bodies. This would indicate that trauma and time are the two factors responsible for the deposition of calcium salts in the cancellous bone of the vertebral bodies.

This area is subject to great trauma by flexion of the spine. In spines with severe scoliosis there is compression and degeneration of the intervertebral disk on the concave side of the curve. If the vertebrae are in contact, they may even undergo spontaneous unilateral fusion.

Changes in the vertebrae will not extend beyond the middle of the adjacent vertebral body, *i. e.*, half way between the superior and inferior surfaces.

Trauma is unmistakably the cause of sclerosis. Following rupture of a disk and collapse of the interspace, the formation of this sclerotic bone will continue as long as the irritation of the vertebral bodies pounding on each other exists.

With our present knowledge of the pathologic physiology of the intervertebral disk and its effects on the vertebral bodies, Cloward believes it can now be stated that the proliferations of bone on the edges of the vertebral bodies which have been called "arthritic" spurs are in the majority of cases traumatic or degenerative disease and not due to infection. Trauma to the vertebrae is secondary to a rupture, degeneration, herniation and collapse of the intervertebral disk, which permits a narrowing of the interspace. In the trauma of everyday movements of the spine, weight bearing, bending and twisting, the edges of the vertebral bodies may come in contact with each other at certain points where the disk is thinned. Whereupon minute but recurrent fractures may occur in the vertebral edges, and each fracture may heal with bony callous formation. As the injuries recur, the callous multiplies, grows larger and a rim of osteophytes may finally develop about the entire periphery of the vertebral bodies above and below a thinned disk. With collapse of the interspace there is a bulging of the disk around its periphery in much the same fashion as an automobile sitting on a flat tire. The proliferations of bone at the vertebral body edges take the contour of the bulging "flat tire" as they develop around it. In the *x*-ray they appear as "eagle beak" or "goose bill" spurs. Osteophytes are only seen when the adjacent interspace is narrowed, giving evidence of a ruptured degenerated disk. They have been designated as "diskogenic" spurs.

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CHAPTER 47

PHYSIOLOGY AND BIOMECHANICS

Armstrong ascribes to the disks three functions: (A) Binding the vertebral bodies together, (B) they form an integral part of the intervertebral joint, permitting movement between individual vertebra, and (C) they transmit the body weight.

Armstrong ascribes to the annulus five main functions: (1) Stability, (2) movement between vertebra, (3) *check ligament*, (4) *nuclear retention*, (5) shock absorbing mechanism.

Armstrong ascribes to the nucleus pulposus first, a shock absorbing mechanism, second, an equalization of stresses, third, fluid exchange between vertebra and disks, and fourth, movement between adjacent vertebra. He ascribes to the cartilaginous end plates the function of first, protection of vertebral bodies, and second, fluid exchange between disks and vertebral bodies.

Biomechanics — The dynamics and biomechanics of the intervertebral disks have been given much attention.

There is no doubt that flexion and extension force the disks to bulge, but there is legitimate argument as to the direction of the bulge. It would appear at first glance that flexion causes a posterior (dorsal) bulge and extension produces an anterior (ventral) bulge. However, the resultant forces acting on the anterior and posterior spinal ligament are variable factors.

Charnley's measurements of isolated lumbar vertebrae revealed that the "bending axis" of the spine lies about 5 mm anterior to the front surface of the spinal theca, which is somewhere in the posterior quarter of the intervertebral disk. The anterior aspect of the dura is closely connected with the maximum movement between flexion and extension, which is only 5 mm over the entire lumbar vertebra. The posterior aspect of the dura, however, is covered by epidural fat and can move a distance of 11 mm. The normal dura does not stretch beyond its maximum length.

Normally the position of the nucleus is at the juncture of the anterior two thirds of the disk and the posterior third. It is in the mid line, equidistant from the anterior surface of the spine and the vertical gliding portion of the posterior articular surfaces. The position of the nucleus, therefore, is in the center of the area of balance. This is the ideal position for movement.

Basic experience demonstrates that the nucleus is the normal axis or fulcrum during the movements of flexion and extension. The height of the disk does not vary regardless of the location of the nucleus but will increase or decrease according to the degree of movement (Calvé-LeLievre).

It has been estimated that the nucleus pulposus maintains its own arterial blood supply up to the twenty-fifth year. This is somewhat

The herniation forward in the intervertebral space, probably through a weakness of the anterior longitudinal ligament, has been demonstrated preoperatively by the Lindblom technic of diskography. This suggested to Cloward that the herniations of torn disk fragments through a thin area of anterior longitudinal ligament, either anterior or lateral, could be responsible for the focal irritation and give a pathologic etiology for local proliferations of bone which result in a single "goose bill" spur formation

analogous to the situation that obtains in the ligamentum teres of the hip joint

Charnley believes that degeneration of a disk is a process of dehydration in which the nucleus pulposus shrinks and becomes fibrotic

The disks showed an increase in weight varying on an average 60 to 100 per cent of the initial weight When the disks were immersed in strongly hypertonic saline solution they took up almost as much hypertonic solution as they did normal saline solution The nucleus pulposus can therefore imbibe fluid against a resistance considerably higher than normal arterial

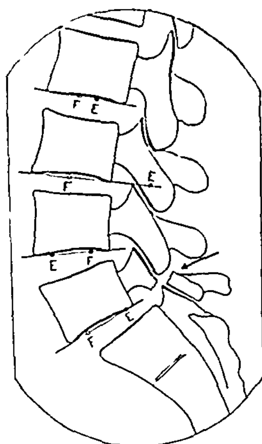


FIG 341 —Spondylolisthesis grade 2 spread of the fulcra at the fifth disk spread and reversal of the fulcra at the fourth articular type of motion at the third normal motion at the second lumbar disk. (Gianturco courtesy of Am J Roentgen)

blood pressure Once the pressure has risen inside the disk, a slight injury may finally complete the bursting of the annulus This fact opens up the possibility of prophylactic treatment of lumbago medically

Mechanogenesis of Disk Lesions —Love and Walsh believe that intervertebral fibrocartilaginous disks protrude posteriorly into the spinal canal as the result of unusual stress or strain applied to the vertebral column The stress may be the result of a single outstanding injury or the result of repeated injuries of varying degrees of severity

Some authors believe the disk is more apt to be protruded when the spine is in flexion and others think it is more vulnerable in extension The

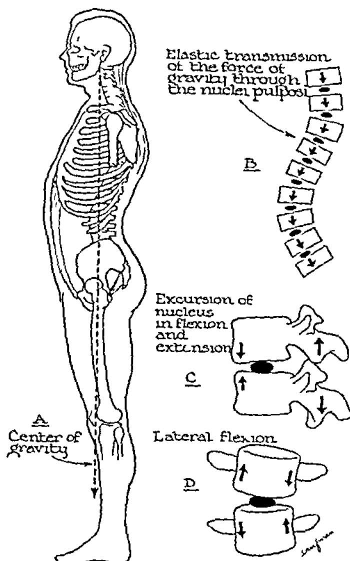


FIG 339 —The mechanics and dynamics of intervertebral disks Balance and transmission of force (Adapted from Calvé and Galland) (Redrawn and modified)

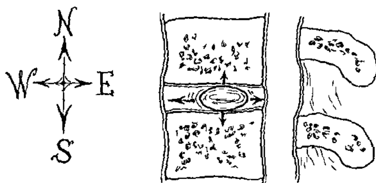


FIG 340 – I visualize the nucleus pulposus as having a limited excursion like a truck on a track in a runway It can move a short distance East and West but none North and South *

* North→Cephalad vertebra South→Caudad vertebra East→Posterior longitudinal ligament West→Anterior longitudinal ligament

The mechanogenesis of disk derangement is
1 Usually a leverage force rather than a direct blow
2 Flexion plus a rotary twist (or lateral shift)
3 One part is stabilized another part is twisted
4 Fibrous tissue is stretched beyond its coefficient of resiliency
5 Hemorrhage
6 Mechanical locking produces a barrier to normal movement
7 Superincumbent weight aggravates other factors
8 Muscle spasm enhances every harmful factor

The mechanogenesis is bound up with (1) The responses and reactions of the disk and other structures (2) The various mechanical forces that affect the intervertebral disks (3) the pathological effect these forces exert on a disk and (4) the operation of these forces

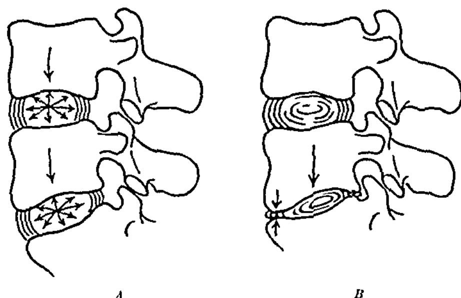


Fig 343 —Normally the nucleus pulposus distributes forces equally over the surface of the vertebral body and the annulus *A* But when the nucelus has been destroyed or extruded weight is no longer equally distributed the vertebral bodies become approximated and there is disorganization of the posterior intervertebral joints *B* (Armstrong courtesy of Jour Bone & Jt Surg)

Friberg studied intervertebral disk punctures in cadavers from twelve to twenty hours after death He found that after he made a hole in the annulus fibrosus of a lumbar intervertebral disk with a trocar having an outer diameter of 4 7 mm he could not make disk material herniate through this hole even though he caused repeated flexion and extension of the spine under pressure and with great force In some instances he exerted as much as 8 kg of axial pressure on the specimens but in no case was a prolapse produced

No lesion can assume much size in the cervical or thoracic regions of the spinal canal without disturbing some nerve pathway and thus calling attention to a compressive lesion However, in the lumbar region a mass may be fairly large before any conduction system is affected Friberg made the experimental observation that herniations up to 8 × 8 × 8 mm

discussion hinges around the relaxation or tautness of the posterior spinal ligament There is no doubt that when the spine is flexed, any specific nucleus pulposus is driven backward, but at the same time the posterior spinal ligament is stretched and made taut because the posterior space occupied by the intervertebral disk is increased

Friberg assumes that during life a nucleus must degenerate before it ruptures, unless the intervertebral disk has been subjected to unusual violence He believes that extremely strong pressure is a prerequisite to protrusion of the annulus fibrosus If the whole nucleus pulposus or a part thereof is loosened, the detached portion alone protrudes

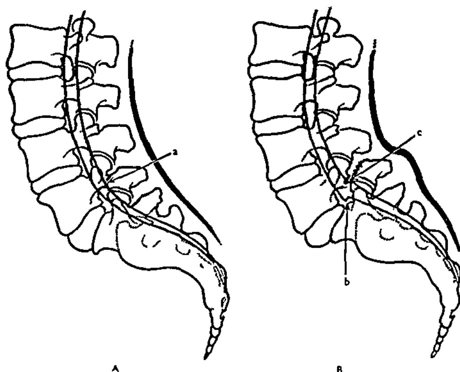


Fig 342 —Mechanism of displacement in spondylolisthesis Linear defects (*a*) exist in the neural arch of one (usually the fifth) lumbar vertebra passing between the upper and lower articular processes on each side *A* The vertebra affected slips forward carrying with it the spinal column above and leaving its neural arch in normal relationship to the vertebra below *B* Two indentations in the spinal canal are produced a lower anterior step formed by the upper and posterior edge of the vertebra below (*b*) and an upper and posterior indentation caused by the anterior shift of the lamina and ligamenta flava of the vertebra above (*c*) (Armstrong Lumbar Disk Lesions courtesy of E & S Livingstone Ltd)

Many facts speak in favor of a mechanical factor in degeneration and rupture of the intervertebral disk

Schmorl connected some of the disturbances of the intervertebral disk with the insertion of the posterior longitudinal spinal ligament This ligament adheres to the vertebral body by only a few thin fibers while its main fibers adhere to the intervertebral disk It spans like a bridge the slightly retracted posterior surfaces of the vertebrae Owing to this, no abnormal traction can act on the ligament and no abnormal ossification can occur

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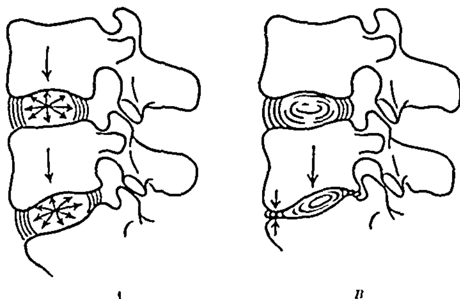


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may lie lateral to the dura and nerve root without producing a demonstrable filling defect in the myelogram During life, it must be assumed that the nucleus has degenerated before it ruptures, unless the intervertebral disk has been submitted to exceptional violence (Friberg)

Walker considered the fundamental mechanism producing the sciatic syndrome to be a mechanical compression of the lower lumbar or sacral spinal nerve roots within the spinal canal The lesion is usually in the lower portion of the lumbar spinal canal, but may be as high as the twelfth thoracic level

Kroll and Reiss feel that the frequent multilocular character of herniation of disks would seem to indicate that degenerative changes in the connective tissue apparatus, rather than traumatic factors are chiefly responsible for this lesion The possibility of herniation of an intervertebral disk as a sequel of spinal puncture with perforation of the posterior longitudinal ligament is discussed elsewhere

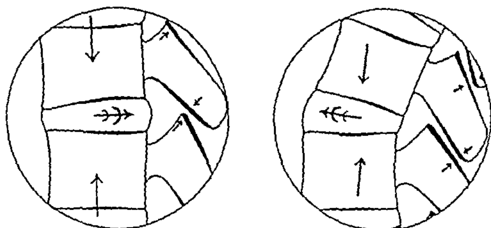


Fig 344 —Stresses upon the intervertebral disks and the posterior articular facets created by extreme flexion and extreme extension (Gianturco courtesy of Am J Roentgen)

Analogy of Automobile Wheels (and Their Tires) and Human Vertebræ and Their Disks —In regard to automobiles one is concerned with wheel construction, position, balance, alignment air pressure in tires and wheel and tire rotation Any automobile expert will tell you that it is wise to "rotate" your car wheels every three months in order to avoid asymmetrical wear and tear on the wheels and especially the tires It would be ideal if humans could rotate their vertebræ and their disks In everyday physical activity we have

Centrifugal Force + { Twists, Rotation, Torsion-Torque }

These aggravate wear and tear on tires One abnormal area on a tire and wheel disturbs *the wheel balance* *An unbalanced tire and* wheel produce a bulge As speed increases there appear flat areas on the tire surface causing "road tramps"

I. Preparatory factors lay the ground work for the blowout.
II. Precipitating factors cause the blowout.

An auto tire may have a "congenital defect" due to a construction defect during manufacture. It may have an "acquired defect" due to old age or from pressure against a sharp curb. This starts the process of local attrition which predisposes to a blowout. Certain auto drivers park their cars at the curb with pressure against a tire, making an indentation, especially parking at an angle to the curb. Auto experts tell us this practice makes most tires more vulnerable to blowouts. One area of the tire suffers the brunt of the pressure.

"Second hand" disks are like reconditioned automobiles—always a risk.

Some disk lesions are definitely due to trauma. This may produce hemorrhage, scarring and more trauma with adhesions. After a period of this situation, when the patient bends forward or backward, there is a pull on the sheath and pressure on the nerve.

The pain pattern of sciatica can be produced by many different etiologic factors. It is most commonly caused by a rupture of one of the lowest two lumbar disks with protrusion of a nucleus pulposus.

There is however a large group of cases of sciatica which are not caused by any intervertebral disk lesion.

From a study of unsuccessful operations for lumbar and sciatic pain, Delchef and Walsh came to the conclusion that spinal arthrosis and other causes, rather than intervertebral disk lesions, are responsible for the sciatic syndrome. Samson and Marino-Zucco came to similar conclusions.

Trauma appears to be the only precipitating cause of acute herniation or slipping of a disk.

Aitken and Bradford report one patient who developed typical disk symptoms while in bed following a collapse of one lung for tuberculosis.

Collapse of an Intervertebral Disk Following Spinal Puncture.—Downing reports 2 cases in which collapse of an intervertebral disk followed operations in which a spinal anesthetic was employed. In both patients the onset of back symptoms and disability appeared shortly after operation, and in both subsequent *x*-ray studies showed partial collapse of the disk between the third and fourth lumbar vertebra. The acutely flexed position of the spine when the puncture is made increases the danger of injury to the disk. The needle should be angulated cephalad so that in case it is inserted too deeply it will strike the posterior surface of the superior vertebra.

Hirsch's investigations support the opinion that fluctuations in pressure that arise in lumbar disks are frequent in ruptures of the annulus. The variability occasioned even by the physiological use of the back may cause irritation of the sensitive end organs of the longitudinal ligaments which produces lumbar pain.

Key and Ford's experiments suggest that the primary lesion which leads to a protrusion of an intervertebral disk is a weakening of the posterior portion of the annulus fibrosus. This may be due to degenerative changes or to injury.

Fay and Chamberlain observed at operation protrusion and retraction of a disk during flexion and extension of the spine. The intervertebral disk

is tough and unyielding The remainder of the spine undergoes proportionately more damage as age advances

Moore believes that the anterior portions of the vertebrae are held apart by the intervertebral disks but the posterior positions that are often poorly constructed mechanically give way to the excessive strain on their ligaments and comparatively weak apophyseal joints Increased lordosis develops, the joints telescope and pain is produced by ligamentous strain, arthritic changes or nerve root pressure at the narrowed intervertebral foramina

CHAPTER 18

ETIOLOGIC FACTORS

THE causes of disk derangements include (1) Primary factors (2) secondary factors, (3) precipitating factors

A disk prolapse can cause (1) Primary effects on a spinal nerve or a disk (2) Secondary effects on a nerve disk joint, or vertebral body

1 *Age* Disk derangements are rarely seen before twenty-one years of age

2 *Sex* Males predominate in a ratio of about 5 to 2

3 *Color* The lesions are about equal in the white and colored races

4 *Trauma* May be physiological i e, due to wear, tear, age, or occupation, or it may be pathological i e, due to injuries both mild or severe

The pain may appear spontaneously, or follow a heavy lift, a sudden twist of the spine or an accident to the spine

The local effects are determined by the anatomical integrity of the disks, the vertebral bodies, their joints and the ligaments which bind them together

5 Developmental anomalies of bones and soft tissue

6 Nutritional disturbances

7 Dehydration—edema

8 Vascular lesions—aseptic necrosis—aseptic absorption

9 Degenerative lesions

10 Arthritis

The most common causes in Falconer, McGeorge and Begg s series were bending strains, minor injuries, and forgotten injuries Accidents had occurred in 44 per cent of their cases

A protruded disk cannot replace itself, any more than a newly hatched chick can get back into its original egg shell Second hand disks are like second hand auto tires Some persons are born with "second hand" disks When an inner tube of an auto tire blows out, the air that escapes never gets back into the tire

The disk situation is mildly analogous to the statement "a live tooth cannot be infected, it must die first A normal disk can withstand a tremendous force before it ruptures A degenerated disk may be ruptured by a very weak force especially if the local mechanical stress is unfavorable

THE INTEGRITY OF THE POSTERIOR LONGITUDINAL LIGAMENT

The integrity of the posterior longitudinal ligament is the crux of the entire herniation situation One desires to know if it is intact bulging or ruptured? The posterior longitudinal ligament is dense in the middle and weak on the sides The physical nature and condition of the nucleus pulposus is largely responsible for the behavior of its intervertebral disk

Approximately half of Speigel's cases give a history of definite injury *preceding the attack. Occasionally a snap in the lower back is felt at the* height of the exertion, which is followed by severe pain. The injuries may be varied—lifting heavy weights, slipping on the ice and jumping from heights are among the commonest. Other patients have no specific history of injury but many state that the symptoms were first noticed after a prolonged period of heavy exertion, or a period of hard manual labor.

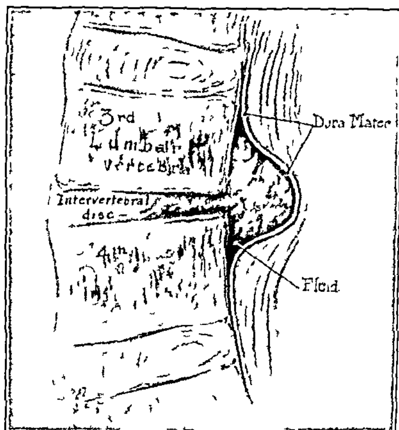


Fig. 345.—Loose cartilage from an intervertebral disk simulating tumor of the spinal cord. (Dandy, courtesy of Arch. Surg.)

The sequence of events in low-back pain and sciatica according to Dandy is: (1) A sudden severe lift or twist tears the capsule at the lateral articulations, and loosens the joints. (2) These loose joints automatically throw an additional strain on the intervertebral cartilages, which constitute the third component in the articulations between the vertebræ. (3) The result of sustained trauma is an injured disk which protrudes and impinges upon the emerging spinal nerve lying in contact with the intervertebral disk.

Armstrong attaches considerable importance to the primary and secondary curves of the spinal column. The primary curves are due to the structure of the vertebral bodies. The secondary curves are due to the form of the disks.

An important cause of pain and limitation of movement is due to the fact that nuclear destruction affects the mechanics of the intervertebral joints.

It isn't the load that breaks you down, its the way you carry it or the improper manner in which you "throw it." The terms "Microtraumatic" or "Petitraumatic" mean repeated multiple minimal trauma.

Flexion + Rotation + A load + Repetition → A Lesion

Twist or Torsion. It's the pivoting of the pelvis or torso that does the damage.

It's the twist or stretch that does the damage.

It's the torsion that produces the protrusion.

It's the rotation that produces the herniation.

A list of potential causes of low back and sciatic pain was drawn up by Barr (See below). Modern concepts of disease suggest that there are multiple important factors in each individual case. Barr warns the surgeon against being trapped into accepting the concept of a single "cause" producing a circumscribed "effect." That narrow viewpoint is the trademark of the cultist. For example, certain surgeons with fanatic ardor seem to believe that a painful back and sciatica are synonymous with a protruded disk and that immediate surgical excision is the equivalent of cure. There are too many such cultists, and each has on his tally sheet a number of therapeutic disasters which, with care, might have been avoided. Those who have studied the problem of low back and sciatic pain, like Barr, recognize that disk lesions frequently produce root pressure and sciatic pain. The lesion may be traumatic in origin, representing normal displaced disk tissue, but much more frequently it is degenerated disk tissue which is displaced. Often degeneration plus trauma (acute or physiological) are coincident factors. The size of a particular disk lesion may vary, increasing because of additional protrusion or decreasing from a process of dehydration. A free fragment of protruded disk tissue may change its location by migration, thus occasionally relieving root pressure.

The most common causes of back pain and sciatica are: (1) Degenerated disks, (2) protruded disks, (3) hypertrophied ligamentum flavum, (4) spinal cord tumors, (5) inflammatory lesions, (6) spondylolisthesis.

There is little doubt that lesions of the intervertebral disks are the most common cause of low back pain with or without sciatica.

If the disk problem is to be solved it will be accomplished by the teamwork of the following persons:

1. General Practitioner
2. Neurologist
3. Orthopedic Surgeon
4. Neurosurgeon
5. Physical Therapist
6. Radiologist

CONCEALED DISK SYNDROME (DANDY)

A concept which created great interest was described by Dandy as the "concealed disk." It is one in which a forceps may drop into the substance of the disk through a small opening. (A forceps cannot sink into a normal disk.) A "concealed disk" is one that protrudes so slightly that it can hardly be found at operation unless the subdural region is explored with

great care Concealed disks make up about 25 per cent of the total cases Symptomatically there is no difference in the manifestations, but at operation the detection of the lesion is more difficult An important argument against the use of spinal contrast mediums is that a concealed disk does not show a filling defect

GYNECOLOGICAL BACKACHE

Uebermuth found that gynecological backache may be due to changes in the intervertebral disks As indications he considers the following a basin-shaped depression of the caudal and cranial vertebral surfaces, also sclerosis of these surfaces, and "transverse areas of hardening" underneath the terminal spongy bony plate of the vertebral body The latter manifestations indicate that the body tends to replace the lost elasticity of the intervertebral disks by a greater solidity Secondary manifestations in the bone develop during the third decade of life This period corresponds to the early manifestations of wear and of age degeneration in the intervertebral disks The circumscribed areas of increased density in the substantia spongiosa underneath the terminal bony plates may be interpreted as calcified cartilaginous nodules or as circumscribed spongiosa plates During the progressive stage the changes bring about disturbances in the static mechanical function of the vertebral column which may cause backache The overburdening of the female vertebral column during pregnancy may be a cause of the disorder

Intervertebral Disk Lesions in Youth —Low-back pain in children and adolescents caused by intervertebral disk protrusions into the spinal canal is common, according to Key but rarely diagnosed The physical signs are less striking in children than in adults The chief complaint may be pain a limp fatigability insomnia or trouble in stooping Disk lesions *occur more frequently in boys than in girls*

The chief location of disk lesions are C5 and C6 and L4 and L5 This localization is based on anatomy biomechanics, biodynamics and biostatics It depends on stress and strain and the resultant of forces

TABLE — —DISTRIBUTION ACCORDING TO AGE AND SEX IN 1 217 PATIENTS OPERATED UPON FOR PROTRUDED INTERVERTEBRAL DISK FROM 1939 TO 1941 INCLUSIVE

Age (Years)	*Total Patients*		*Males*		*Females*	
	Number	*Per Cent*	*Number*	*Per Cent*	*Number*	*Per Cent*
10 to 19	25	2 1	20	2 3	5	1 4
20 to 29	198	16 3	137	16 1	61	16 8
30 to 39	430	35 3	301	35 2	129	35 5
40 to 49	371	30 5	252	29 5	119	32 8
50 to 59	160	13 1	118	13 8	42	11 6
60 to 69	33	2 7	26	3 1	7	1 9
Totals	1 217	100 0	854	100 0	363	100 0
Averages	39 4 years (16 to 68 years)		39 4 years (16 to 68 years)		39 2 years (16 to 67 years)	

Love Jour Bone and Joint Surg 29 No 2 April 1947

Color—In an investigation regarding the relative frequency of disk protrusion in the colored race, I asked Love and Lincher for their experiences. I am indebted to Lincher for the following statements

It is the over all impression that perhaps the percentage of disks in the negro is not the same ratio to population as the ones seen in the white race The condition, however is by no means a rarity in the colored race, occurring more commonly in the men than women and more commonly from thirty to forty-five than in the pre- or post-decades, as in the white people, lumbosacral or lumbar four five, are the common levels In ratio to the proportion of low back instabilities in the colored races compared to the white, Lincher finds that low back instability in the white is about four times more common than it is in the colored, but the ruptured disk proportions are about equal

Love remarked that, 'perhaps the negro has a stronger posterior longitudinal ligament, than does a white man Another factor, which enters is that negroes as a rule do not look forward to surgery with any degree of pleasure ' Love has operated upon several negroes for protruded disks

FRACTURES OF INTERVERTEBRAL DISKS

Fractures of disks are generally due to compression injuries or to falls from heights The disk flattens out and projects, usually backward, causing pressure on the spinal cord or its peripheral nerves Damage to the disk is evidenced by partial loss of the spaces adjacent to the broken bones If the force is concentrated or exerted on the vertebra above and below, a cup-shaped double concave depression is produced in the contiguous vertebræ (Schmorl's Node)

LUMBAR PUNCTURE INJURY TO INTERVERTEBRAL DISKS

Traumatic Diskosis—Traumatic Diskitis

In 1924 Billington reporting on spondylitis following cerebrospinal meningitis stated that 12 of 14 cases he studied showed pathological changes in the lumbar region In explaining these findings he conjectured the possibility that the vertebræ had been affected by trauma caused by the lumbar puncture needle and by direct inoculation with the meningococcus from the passage of the needle through the infected spinal fluid

In the first edition of a book called Cerebrospinal Fluid by Abraham Levinson there appears on page 63, the statement ' There are times when no fluid can be obtained in spite of all efforts Among the factors responsible for the failure to obtain fluid are

'1 The needle may not have been inserted far enough into the spinal canal

2 The needle may have been inserted too far into the canal In such a case the material exuding from the intervertebral disk may plug the needle "

THE RELATION OF DISK LESIONS TO DEGENERATIVE ARTHRITIS OF THE SPINE

Elaborating on the classical investigations of Schmorl and Junghanns, Keefer reconstructs the course of events in degenerative arthritis of the spine. The changes start with disk degeneration: loss of fluid content of the nucleus pulposus, degeneration, breaks in the cartilage and displacement of the disk tissue into the spongiosa of the vertebral bodies. The essential lesion is a degeneration of the disk. This is followed by increased movability of the vertebrae upon each other, and later, when the disks become fibrosed, there is generalized rigidity of the spine. The decrease in height of the disk is followed by increased pressure upon the borders of the vertebrae, the edges become flattened and are forced outward, forming irregular bony excrescences. These changes have been produced experimentally in dogs by Keyes and Compere by puncturing the disks with a needle permitting a part of the nucleus pulposus to escape and the vertebral bodies to approximate one another.

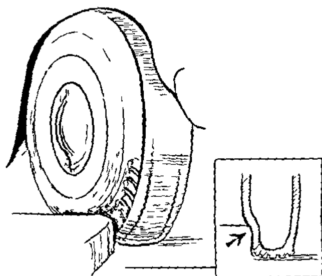


Fig. 34f.—Compression bruise of an auto tire parked at a curb causing a weak spot.

CHAPTER 19

THE HISTORY, SIGNS AND SYMPTOMS

The history is very important etiologically, diagnostically and therapeutically. Armstrong finds that 60 per cent of all patients with lumbar disk lesions give a history of some form of injury and that the other 40 per cent give no history of any injury whatever.

The most important symptom is pain in the back and one leg. It may be referred to a buttock, hip, calf or foot. It usually wakens the victim from sleep and is aggravated by any physical activity. It is usually relieved by rest in bed, the fetal posture, compression or stabilization of the back and pelvis, medicine and the use of crutches.

The pain usually appears in recurring attacks, but may be continuous, and in many cases becomes constant. Movements of the spine, torso or pelvis intensify the pain. One should inquire regarding pending compensation, any medico-legal controversy or psychological factors.

1 *Typical History*.—I shall summarize the important points in an actual case of a protruded disk as follows:

1. His original attack was brought on by a physical strain.
2. He has had four definite previous attacks.
3. In all attacks preceding the last, the pain was always localized to a small area below the waist line. In the last attack severe pain "shot down" his right leg into his toes.
4. He has always been able to sleep through those attacks which preceded the last. During the last attack the pain forced him to get out of bed about 2 o'clock every morning. He would take a warm bath, move around a little, sit in a chair and read a while. Then he was able to go back to bed and sleep three more hours.

This story indicates a mechanical pressure on one of his spinal nerves. Formerly it was considered, to be a characteristic story of a *spinal cord tumor*. Now it is recognized that about 95 per cent of these cases are due to disk syndromes and about 95 per cent of all disk lesions involve the 4th and 5th lumbar disks.

The examiner should always listen attentively to the patient's story of his complaint. One cause of operative failure after exploration of L4 and L5 spaces is illustrated by the statement: "But doctor I told you about the pain in my groin." (Indicating L3 or L2)

Episodes.—The person with a classical herniated disk syndrome presents a characteristic history of episodes of pain. Each succeeding one is more severe than the preceding one. Spiegel discusses several explanations for the episodic nature of this condition. If the posterior longitudinal ligament is not torn the disk may gradually return to its normal position, with subsidence of symptoms.

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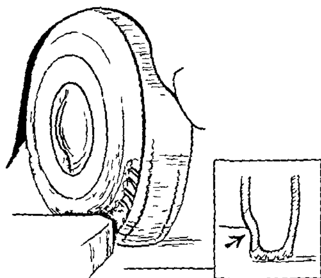


Fig. 346.—Compression bruise of an auto tire parked at a curb causing a weak spot

CHAPTER 49

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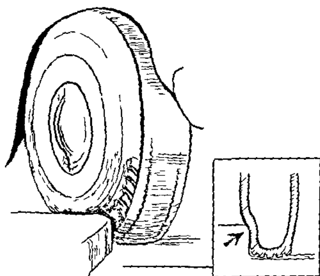


Fig. 346.—Compression bruise of an auto tire parked at a curb causing a weak spot.

size of the canal As a result the tear in the posterior longitudinal ligament and the annulus fibrosus is further irritated by the disk pressing upon it, and the nerve root is further irritated by increased pressure of the mass A concomitant of straining is increased intracranial pressure This causes a change in the relative positions of the herniated disk, the irritated nerve roots and the posterior longitudinal ligament with resultant exacerbation of pain

Aggravation by Exercise —Aggravation of low back and radiating sciatic pain by movements of the pelvis or torso is characteristic of a herniated disk syndrome Some patients are most comfortable when standing Bending forward may cause severe pain as may any sudden movement of the back Exercise irritates the sensitive nerve root and causes or aggravates radiating pain

Paresthesias—Location —Paresthesias are frequently reported early in the course of trouble, before actual hypesthesia sets in They consist of tingling or burning sensations Occasionally the patient complains of hyperesthesia The paresthesias are in the same location as the pain and are due to irritation of the nerve roots Their location is a good diagnostic aid

Numbness —Numbness is in the same distribution as the paresthesias and usually occurs later Its degree varies with the amount of physiological interruption of nerve function which has occurred As time goes on and the pressure continues, the interruption of function may become irreversible due to permanent changes in the nerve Localized areas of numbness are valuable diagnostic aids

The occurrence of *cramp* as a symptom, in sciatica due to a prolapsed intervertebral disk, was studied by Woltman in a series of 204 cases The incidence of cramp was found to be higher after operation when, in addition to removal of the protruded disk material, a posterior nerve root had been cut

Paresthesias in the dermatome supplied by the compressed nerve are helpful in the diagnosis and localization of the protrusion

Sphincteric disturbance usually means that a very large but low lesion is present, producing a complete subarachnoid block

A high percentage of patients give a history of intermittency of symptoms Intermittency serves as a useful criterion in distinguishing between root pain caused by a protruded disk and that caused by an intraspinal neoplasm The latter is characterized by definite progression of symptoms and signs without remissions

A nucleus pulposus may herniate bilaterally, producing a dumbbell deformity A mid-line herniation may produce bilateral symptoms In such cases the clinical picture sometimes resembles that of a tumor

Physical Examination —Love insists that the patient should be examined while disrobed in a well-lighted room, and his gait should be carefully observed Any patient who has a protruded intervertebral disk and is not paralyzed—no matter how great the pain—should be able to stand beside his bed so that his posture can be observed The patient usually guards his spinal movements and frequently walks with a limp and with a list of the trunk, either away from or toward the painful side The back usually

In those instances where the posterior longitudinal ligament is torn, with actual extrusion of disk material into the spinal canal, the material may gradually work its way from one position to another, on one occasion, exacerbating the pain and on other occasions, permitting remission of symptoms Each major change in position follows an injury such as slipping or lifting

It is highly improbable that a herniated disk can return to its normal habitat through a tear in the posterior longitudinal ligament Another explanation for the episodic nature of the lesion is that the spinal nerve on being stretched backwards by the herniated disk, slips over it to one or the other side and a remission of symptoms can occur When the herniated mass moves once more, it may again impinge on the nerve and cause an exacerbation of symptoms

Continued pressure on a nerve will eventually cause it to cease functioning This may explain some of the cases of gradual diminution of pain If the pressure involves only one nerve root, the neurological deficit may be quite small If the herniated mass moves again, the entire chain of events may be repeated

Back Pain—The first symptom is usually low back pain This frequently precedes the onset of sciatic radiation The chief cause for the low back pain is actual tearing or stretching of the posterior longitudinal ligament and the annulus fibrosus These two structures are well supplied with sensory fibers Displacement of a herniated disk also causes a change in the relationship of at least two vertebral bodies This may pull on the ligaments surrounding the facets causing localized pain A mid line protrusion causes backache only when it is very large or consists of the greater part of the posterior annulus

The most common symptoms and signs and those which are of the greatest value in arriving at a clinical diagnosis of protrusion of a lumbar disk are unilateral or bilateral sciatic pain This usually interferes with sleep This is an important symptom when present It is particularly suggestive of a lesion of a nerve root but it is much more striking in cases of intraspinal neoplasm than in cases of protruded disk Another indication of involvement of a nerve root is accentuation of the pain on coughing sneezing or straining at stool

I have been able to localize many lesions by giving the patient a pinch of snuff to cause a sneeze or two, which accentuates and localizes the pain

Radiation of Pain—The most frequent sites of radiation of pain are into the buttock, hip, the postero-lateral aspects of the thigh, knee, leg and ankle Occasionally the pain is referred to the great toe or to the dorso-lateral aspect of the foot and the lateral toes

Aggravation by Coughing and Sneezing—Aggravation of the pain by coughing or sneezing is significant and generally indicates the presence of a space occupying lesion The mechanics of this symptom are simple The intra abdominal pressure is raised by coughing sneezing and straining, forcing blood out of the inferior vena cava, through the lumbar veins into the spinal canal This increases the circulation in the canal and causes a temporary swelling of all the components in this area The net result is an increase in the size of the contents of the canal with no increase in the

intensifies the back pain and may reproduce the whole pattern of leg pain, even the sensory disturbances

Hyperextension Test — The patient lies on his back with his legs hanging over the foot of the table In a unilateral case the patient cannot drop the leg on the painful side Flexion of the well thigh reduces the degree of pain Flexion of both should afford still more relief

The Radiation Compression Test —The patient bends forward and the examiner applies pressure by means of his thumb or the reflex hammer to produce pain

Atrophy — Atrophy may be measured accurately at equal distances from fixed levels such as the malleoli and the anterior superior spines Atrophy results from disuse because of voluntary guarding of the limb, and from actual muscular atrophy due to evanescent damage or permanent destruction of the motor nerve to the muscle Occasionally fibrillations are observed in some of the muscles

Weakness —In advanced cases of herniated disk definite motor weaknesses may be demonstrated, due to prolonged injury to the nerve roots If severe actual foot drop may be observed as a result of partial paralysis of the anterior and lateral tibial musculature which is innervated by the lower lumbar and upper sacral nerve roots Similarly, involvement of these roots may occasionally cause weakness of abduction of the thigh and flexion of the knee

SCIATIC SCOLIOSIS

Young finds that sciatic scoliosis and the less common scoliosis with back pain only (Lumbago-scoliosis) are nearly always associated with a protrusion of the disk below L4 A protrusion of the disk below L5 does not cause severe scoliosis although it is quite common for it to cause a slight lateral tilt or list on forward bending Young observed that if the protrusion is lateral to the root, the tilt will be away from the side of the pain (heterolateral) because, in this attitude, the root tends to be removed from pressure However if the disk is more centrally placed or in the axilla of the root the tilt will be towards the painful side (homolateral) as this provides the most relaxed position for the root

ALTERNATING OR REVERSIBLE SCIATIC SCOLIOSIS

Occasionally one encounters a situation of alternating scoliosis A protrusion near the mid line should be suspected in such cases Moore observed the case of a young man whose body was drawn forward and far to one side with unilateral radiating pain He had had repeated attacks with radiation of pain to the opposite side with an opposite list of the spine He was able voluntarily to produce the change Slowly he strained himself to the erect position with increasing pain Suddenly his body torso swung to the opposite side in which position it remained in order to give him some relief from pain At operation Moore found a very large centrally displaced protruded disk I described and illustrated a similar case thirty years ago

is flattened, with loss of normal lumbar lordosis, and the erector spinae muscles are in spasm All movements of the lower part of the back may be limited, lateral bending in the direction of the list is usually greater than toward the opposite side, and hyperextension is painful This latter movement if forced, may even cause the patient to collapse Usually there is local tenderness in the region of the spinous processes of the fourth and fifth lumbar vertebrae The result of the straight-leg raising test is almost always positive on the side on which pain occurs and, when the opposite extremity is elevated in cases of unilateral sciatic pain, the extent of movement is at times limited with reference of pain to the involved opposite member Kernig's sign is usually elicited

In the vast majority of cases a diagnosis of protruded intervertebral disk can be made or ruled out by this time, but a neurological examination should be made in every case

Limp —The patient with a large herniated disk favors the involved extremity When walking, the thigh is not flexed forward to the normal degree and the ankle is not dorsiflexed to the normal degree Complete extension of the knee is avoided When standing, the knee and hip are slightly flexed and the foot is plantar flexed

Body List —There is frequently seen a list of the entire body toward the side of the lesion Besides this, the patient may have a scoliosis with the convexity toward the normal side This may be due to the voluntary splinting of the lumbosacral paravertebral muscles to prevent painful movement, with more spasm on the involved side pulling the vertebrae together producing scoliosis The trunk list to one side is due to the fact that the patient assumes a position which causes the least pressure on a nerve and the least tension within the nerve

Lumbar Lordosis —Spasm of the paravertebral muscles results, in about 70 per cent of cases, in complete or partial loss of the normal lumbar lordosis

Lumbosacral Paravertebral Muscle Spasm —The muscle spasm may be most severe on the involved side

Spurling and Thompson find that most persons with a herniated nucleus pulposus have a straight lumbar spine with obliteration, or reversal of the normal lumbar lordosis Most of them show listing away from the side of the sciatic pain In almost every instance the pelvis is on the affected side is higher than on the normal side Movements of the lumbar spine are usually limited especially in flexion Extension of the spine is often painful The erector spinae muscles may be in a state of spasm which may be greater on the side opposite the lesion Light percussion or pressure at the level of the lesion will usually demonstrate an area of localized tenderness Deeper percussion just to the side of this tender area may cause pain to radiate into the gluteal region or leg

Radiating percussion pain may be caused by waves of force transmitted through the ligamentum flavum to the affected nerve roots at the site of the lesion When positive this sign is almost pathognomonic of a herniation of a nucleus pulposus

Lateral bending is often restricted, particularly toward the painful side Bending forcibly toward the painful side for thirty to sixty seconds usually

through on the other side Patrick called this test the *fabere sign, from* the initial letters of the movements necessary to elicit it, flexion, abduction, external rotation and extension of the thigh I have never seen a proven case of an irritative hip disorder that did not have a positive fabere-Patrick test

A disturbance of the **Achilles tendon reflex** is compatible with a protrusion at the fifth lumbar space *Love frequently found* the Achilles reflex absent when protrusion of the fourth lumbar disk had occurred It was often present when protrusion of the fifth disk had been proved To test the Achilles reflex, the patient kneels on a chair with his back to the examiner and his feet protruding over the edge of the chair The patient grasps the back of the chair (like a Jendrassik reinforcement of the patellar reflex) The response to varying degrees of tapping on the tendon is noted

Where root tension or irritation rather than compression is associated with nuclear retropulsion, Armstrong describes the sequence of events as follows The motor fibers of the root appear to be less affected than the sensory fibers and muscle weakness or wasting is relatively less severe than pain or sensory disturbance Gross muscle wasting is a late sign, as is weakness sufficiently severe to be detected by the patient

Muscle wasting should be sought in the buttocks in the thigh and in the calf The buttocks should be examined while the patient stands When the gluteal muscles are contracted it is possible to observe minor degrees of difference between the two sides

The muscle bulk of the thigh is measured with the patient lying supine and the muscles relaxed The circumferences of the thighs are measured at varying distances above the upper pole of the patella and compared The calf is measured in a similar manner Muscle power is tested in relation to movement of the hip, knee ankle joint and foot

Movements of the Hip —The patient lies supine and first one and then the other hip is flexed this movement being resisted by the examiner The power of adduction and abduction is then tested against resistance

The Power of Knee Movement —Flexion and extension are carried out against resistance by the examiner and any loss of power in the quadriceps or the hamstring muscle groups on one side is noted

Movements of the Ankles and Toes — This is most important Positive findings in relation to the power of these movements enable the examiner to differentiate between lesions involving the fifth lumbar and first sacral roots the two roots which are most commonly affected in lower lumbar disk lesions Dorsiflexion and plantar flexion of the ankle are tested first and the power of each of these movements is estimated in two ways Firstly the movements are carried out against resistance If the muscle power is normal the patient with an average physique should be able to dorsiflex or plantarflex the ankle in spite of the maximum resistance which can be offered by the examiner The patient is then instructed to hold the ankle in full dorsiflexion and in full plantar flexion and to maintain these positions while the examiner tries to force the foot downward or upward Again provided there is no loss of muscle power the patient of average physique should be able to maintain either of these positions in spite of all the force which the examiner can apply

CHAPTER 50

PHYSICAL EXAMINATION—SIGNIFICANT FINDINGS

This is the appropriate place to review the tests described in the chapter on Basic Principles

Various Tests.—(1) *Technic of Elicitation*.—Each maneuver must be carried out precisely

(2) The significance of each test must be interpreted and evaluated according to these two criteria (*a*) Is it compatible with certain lesions, (*b*) is it incompatible with certain lesions

During the examination, one should observe for evidence of emotional instability

Flexion of Spine.—A dependable finding in herniated disk cases, is diminution of "forward" flexion of spine In addition to pain, voluntarily limiting flexion, the paravertebral muscular spasm acts as an involuntary protective splint to reduce movement

Lateral Flexion.—Limitation of flexion to the side opposite the lesion is a frequent finding The stretching of the irritated sciatic nerve may cause radiation of the pain along its course Squatting with buttocks between heels and head flexed usually affords relief

The Lasègue-Goldthwait Straight-Leg Raising Test.—The patient lies supine with his heels projecting over the foot of the examining table Each straight leg is raised from the table very gently The examiner estimates or measures the angle subtended by the leg and the examining table when he recognizes a protective muscular resistance or when the patient complains of pain or when he begins to squirm or when the opposite knee begins to flex

When positive it means that putting the hamstring tendons on a stretch causes pain It "puts the pull on the structures in the posterior region of the thigh and pelvis This pull is transmitted to the lower back The Lasègue sign indicates the degree of pain It is also an index of progress or retrogression

The Kernig test is elicited by another route The patient lies supine, (1) the knee is flexed (2) the thigh is flexed on the abdomen to a right angle (3) the knee is extended When the test is positive the knee cannot be extended

In any disease where irritation of the components of the sciatic nerve is present, pain will be elicited along the course of the nerve It is said to be due to stretching the nerve

The Fabere-Patrick Test.—In performing the fabere-Patrick test the patient lies supine The right thigh and knee are flexed and the external malleolus is placed above the left patella Then the right knee is depressed If pain is produced thereby or if the knee cannot be depressed, it indicates a lesion in or around the right hip Then the same maneuver is carried

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Finally inversion and eversion of the foot are tested against resistance

The muscle distribution of the various roots which may be involved in lumbar disk lesions is shown in Table 3. Since the vast majority of lesions affect the L4 to L5, or L5 to S1 disks, the roots most often involved are the fifth lumbar and first sacral. The fourth lumbar root is occasionally affected and, very rarely, the second and third roots may be irritated by the uncommon lesions of the upper lumbar disks. For the purposes of clinical examination **root function** has been interpreted by Armstrong in the table in terms of **joint movement** rather than in terms of distribution to individual muscles or muscle groups.

The **second lumbar root** forms part of the motor supply of the flexors, adductors and internal rotators of the hip and, as far as the leg is concerned, is related to movements of this joint only.

TABLE 3.—THE CLINICAL PICTURE IN LUMBAR DISK LESIONS*

Root	*Buttock*	*Hip*	*Knee*	*Ankle and Toes*	*Foot*
2nd Lumbar	Nil	Flexion Internal rotation Adduction	Nil	Nil	Nil
3rd Lumbar	Nil	Flexion Internal rotation Adduction	Extension	Nil	Nil
4th Lumbar	Supplies gluteus medius and minimus (superior gluteal nerve) Quadratus femoris and inferior gemellus (nerve to these muscles)	Extension External rotation Abduction	Extension	Dorsiflexion of ankle and toes	Inverts foot
5th Lumbar	Supplies gluteus medius and minimus (superior gluteal nerve) Quadratus femoris and inferior gemellus (nerve to these muscles) and gluteus maximus (inferior gluteal nerve) piriformis and superior gemellus (nerve to these muscles)	Extension External rotation Abduction	Flexion	Dorsiflexion of ankle and toes	Everts foot
1st Sacral	Supplies gluteus medius and minimus (superior gluteal nerve) Quadratus femoris and inferior gemellus (nerve to these muscles) and gluteus maximus (superior gluteal nerve) piriformis and superior gemellus (nerve to these muscles)	Nil	Flexion	Plantar flexion of ankle and toes	Everts foot

* (ARMSTRONG courtesy of Williams & Wilkins.)

TABLE 4.—LUMBO-SACRAL PLEXUS
SPINAL ROOT—NERVE—MUSCLE CHART*

Root						
L3	L4	L5	S1	S2	*Nerve*	*Muscle*
						Spinal Muscles
+	+	+			Dorsal rami	Intertransversarii
+	+	+	+	+	Dorsal rami	Longissimus
+	+	+			Dorsal rami	Multifidus
+	+	+			Dorsal rami	Rotatores
+	+	+			Dorsal rami	Interspinales
+	+				Ventral ramus	Quadratus lumborum
						Muscles of the Lower Extremities
+	+				Femoral	Iliacus
+	+				Femoral	Quadriceps femoris
+	+				Obturator	Adductor brevis
+	+				Obturator	Obturator externus
+	+				Obturator	Adductor magnus
	+	+	+		Ventral ramus	Quadratus femoris
	+	+	+		Ventral ramus	Gemellus inferior
	+	+	+		Superior gluteal	Glutaeus medius
	+	+	+		Superior gluteal	Glutaeus minimus
	+	+	+		Superior gluteal	Tensor fasciae latae
	+	+			Peroneal (deep)	Tibialis anterior
	+	+	+		Peroneal (deep)	Extensor hallucis longus
	+	+	+		Peroneal (deep)	Extensor digitorum longus
	+	+	+		Peroneal (deep)	Extensor digitorum brevis
	+	+	+		Peroneal (deep)	Peronaeus tertius
	+	+	+		Peroneal (superficial)	Peronaeus longus
	+	+	+		Peroneal (superficial)	Peronaeus brevis
	+	+	+		Tibial	Plantaris
	+	+	+		Tibial	Popliteus
	+	+	+		Medial plantar (tibial)	Lumbrical (first)
	+	+	+		Medial plantar (tibial)	Abductor hallucis
	+	+	+		Medial plantar (tibial)	Flexor hallucis brevis
	+	+	+		Medial plantar (tibial)	Flexor digitorum brevis
		+	+	+	Inferior gluteal	Glutaeus maximus
		+	+	+	Sciatic (com. peroneal)	Biceps
		+	+	+	Sciatic (tibial)	Semitendinosus
		+	+	+	Sciatic (tibial)	Semimembranosus
		+	+	+	Tibial	Flexor hallucis longus
		+	+		Tibial	Flexor digitorum longus
		+	+	+	Tibial	Soleus
		+	+		Tibial	Tibialis posterior
			+	+	Ventral ramus	Obturator internus
			+	+	Ventral ramus	Gemellus superior
			+	+	Ventral ramus	Piriformis
			+	+	Tibial	Gastrocnemius
			+	+	Lateral plantar (tibial)	Adductor hallucis
			+	+	Lateral plantar	Abductor digiti quinti
			+	+	Lateral plantar	Flexor digiti quinti brevis
			+	+	Lateral plantar	Quadratus plantæ
			+	+	Lateral plantar	Interossei

* J. S. BARR: Low Back and Sciatic Pain, July 1951. Courtesy of J. B. & J. S. Adapted from Favill's *Outline of the Spinal Nerves*, Springfield, Illinois: Charles C Thomas, 1946.

The **third lumbar root** is concerned in both hip and knee movement. Its distribution to the hip is the same as that of the second lumbar root, that is, it supplies *the flexors, adductors and internal rotators* and it also forms part of the supply to the quadriceps muscle group and hence is concerned with extension of the knee.

The **fourth lumbar root** supplies the gluteus medius, gluteus minimus, *quadratus femoris and inferior gemellus muscles in the buttock through* the superior gluteal nerve and the nerve to the inferior gemellus and quadratus femoris. It is concerned in extension, external rotation and abduction of the hip joint, in extension of the knee joint, in dorsiflexion of the ankle joint and of the toes and *in inversion of the foot. From the point of view* of motor power irritation of the fourth lumbar root is most likely to be confused with irritation of the fifth lumbar root. Lesions of both roots may be associated with wasting in the buttock, loss of power of extension, ex*ternal rotation and abduction of the hip and of dorsiflexion of the ankles* and toes. Whereas the fourth root is concerned with extension of the knee and inversion of the foot however, the fifth root supplies muscle groups which perform the exact opposite of these movements that is this latter *root is concerned with flexion of the knee and eversion of the foot.*

The fifth lumbar root has a wide distribution to all the muscles of the buttock through both the superior and inferior gluteal nerves the nerve to the piriformis and superior gemellus and the nerve to the quadratus femoris and inferior gemellus. It is also concerned with extension external rotation and abduction of the hip.

Astrom Suspension Test.—Astrom observed that two soldiers who were discharged from the Army because of sciatica and backache, did not bend over normally when picking up their shoes and lacing them. They stood on the good leg with the trunk erect and bent the affected lower extremity at the hip and knee to reach the foot with the hands. This relieved the tension on the sciatic nerve. Both these men were suspended by their hands holding on to the top part of a door so that their feet did not touch the floor. In this position Astrom tapped their lumbar regions with his fist. This tapotement did not elicit any pain. When they stood on their feet, tapotement of the lumbar region did elicit pain. Suspension of the body by the hands causes the weight of the section of the body below the sacrolumbar articulation to exert sufficient traction to cause the herniated portion of the nucleus pulposus to retract so much that for the moment there is no pressure on the spinal nerve roots which ordinarily causes the sciatica.

A New Sign in Some Disk Syndrome Patients.—*One of my* World War II colleagues Col. X himself a victim of herniation of a nucleus pulposus called my attention to a new sign in this syndrome. This is a characteristic walking gait, due to inequality of the length of steps. The affected person takes a shorter step on the affected leg. My explanation is that his gait is a mild repetition of the Lasegue test while walking. When positive the sign is of some significance.

Knee Jerk.—This reflex is characteristically diminished in lesions involving the second, third and fourth lumbar nerves. It is performed by tapping the patellar tendon while the patient sits and the legs dangle. The

reflex may be increased, due to irritation of a nerve root Diminution or the reflex is due to pressure on the nerve root which mediates the motor and sensory impulses constituting the reflex

Ankle Jerk —Diminution or absence of the ankle jerk, when present is a dependable sign of a herniated disk below L4 or L5 It was present in over 90 per cent of Speigel's surgically proven cases and has been found to be far more common in the herniations below L5 Loss of this reflex is due to interruption of the reflex tracts through either L5, S1 or S2 The test is easily accomplished by having the patient "stand on his knees" on a pillowed chair with his feet projecting backward over the edge of the chair This posture minimizes voluntary or conscious inhibition of the reflex

Sciatic Tenderness —This is an infrequent finding in a herniated low lumbar and lumbosacral disk It is due to irritation of the involved nerve fibers by pressure of the herniated mass on the nerve root This tenderness can be elicited by pressing midway between the ischial tuberosity and the trochanter of the affected side Frequently this tenderness can be elicited all along the course of the sciatic and tibial nerves

Radiation of Pain on Percussion over the Spine —Tenderness to percussion over the spines of the involved vertebrae is an indicator of the level of the lesion With the patient bending over slightly to separate the lumbar spines, they are gently tapped with a percussion hammer If a herniated disk is present at the level percussed, pain will occur in the region and not infrequently will radiate down through the buttock, hip, thigh, knee, leg and ankle The pain in the low back is due to the irritation of ligaments The radiating pain is due to irritation of the nerve root Spurling finds this radiation of pain on percussion over the spine to be a dependable diagnostic test

Lewin Test —A sharp blow with a fist against the patient's buttock may aggravate the pain I had one patient who found that by punching his right buttock he was able to reproduce the pain on his right side whereas punching his left buttock caused no pain He had a right-sided protrusion of the 4th lumbar disk This is the reverse of the Queckenstedt test It is a test that is worthy of performance but should not be given too much prominence If it is positive it is confirmatory evidence I have been able to localize many lesions by giving the patient a pinch of snuff to cause a sneeze or two which aggravates his pain

CHAPTER 51

NEUROLOGIC EXAMINATION FOR DISK DISORDERS

A NEUROLOGICAL examination is most valuable

Reflexes —The deep and superficial reflexes should be tested

Skin Sensorum —The dermatomes should be outlined for hypalgesia

Muscle Power —Should be tested

Electrical Responses —Faradic stimulation of hyperalgesic nerves may be helpful

The neurological examination must be precise and complete The sheet anchors of neurological diagnosis are an accurate history followed by a complete examination

The neurological observations in cases of lumbar protruded intervertebral disk not complicated by paraplegia, include diminution or absence of the Achilles reflex, and sensory changes in the skin of the outer side of the leg and the outer and upper surfaces of the foot Love finds that loss of motor power is infrequent, although some degree of atrophy of the calf muscles is not uncommon Occasionally, complete footdrop is seen, resulting from a lesion involving one nerve root There is so much variation in the formation of the lumbosacral plexus and the lower part of the back that space-taking lesions cannot be localized consistently in this region by the neurological method Frequently, the Achilles reflex is absent when protrusion of the fourth lumbar disk has occurred and it may be present when the protrusion of the fifth disk has been sustained Protruded disks are often seen in patients who have four or six lumbar disks Similarly, intraspinal neoplasms sometimes give the same neurological picture as protruded intervertebral disks Protruded intervertebral disks can be accurately localized by determination of the dermatome involved Many protruded disks cannot be localized by other neurological methods

A protruded intervertebral disk in the lower part of the lumbar region can compress the cauda equina sufficiently to produce ascending edema of the cauda equina with a dermatome level much higher than the actual site of the lesion

Naffziger Sign —This test is performed by digitally compressing both internal jugular veins for a few seconds An effective way to perform this test is to have the examiner face the patient's back and compress both jugular veins with the index and middle fingers of each hand

A more accurate method is to place a blood pressure cuff around the neck and inflate it to a pressure of about 40 mm of mercury for a few seconds and observe the results

In the patient with a true herniated disk, the radiating sciatic pain is either reproduced or aggravated by this maneuver The test is most frequently positive in those patients who have a history of aggravation of the pain by coughing and sneezing Occasionally the pain is not aggra-

vated until the finger is released When the jugular veins are compressed, there is a damming back of blood in the head with resultant increased intracranial pressure The pressure is reflected throughout the entire subarachnoid space causing distention of the dura in the involved area, movement of the irritated nerve roots and pain The patient should be instructed not to hold his breath or strain while undergoing the test

Sensory Loss —This is one of the most dependable signs of a herniated disk and is elicited by passing a dull pin from the normal to the anesthetic area For this test, it is necessary to be well acquainted with the sensory areas innervated by the various dermatomes With herniations below L5, the most frequent sensory loss is over the lateral aspect of the leg, the

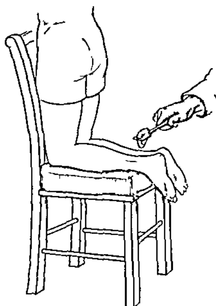


Fig 347 —Patient kneeling for test of Achilles tendon reflex

dorso lateral and plantar aspects of the foot and the lateral three or four toes With herniations below L4 the most frequent sensory loss is over the medial portion of the dorsum and sole of the foot and over the dorsal and plantar surfaces of the great toe

Radiation of pain to the great toe or to the dorso-lateral aspect of the foot and the lateral toes can be explained by the fact that the mass presses on all, or one, of the nerve roots of L4, L5, S1 and S2 The pressure irritates the sensory nerves causing radiation of pain to the area supplied Speigel finds in those cases where there is actual pain radiating to the great toe, there is generally a herniation below L4 In the more frequent cases where the pain radiates to the side of the foot and the lateral toes, the usual finding has been a herniated disk below L5 This by no means is an infallible rule since a herniated disk below L4 may press on all the above-mentioned nerve roots

Neri described a diagnostic measure that is useful in differentiating spinal lesions It consists of faradic cutaneous stimulation which elicits

hyperalgesia of the corresponding dermatome Direct manual pressure often produces a negative response and offers no clue as to the underlying pathologic change Like the rectus abdominus muscles, the erector spinae muscles manifest metameric innervation by the posterior branches of the spinal nerves Because of this type of innervation, one can recognize changes in response to the electric current limited to that section of muscle that is solely innervated by one posterior branch of a spinal nerve

The cathode is placed in the paravertebral region and slowly moved down the length of the spinal cord, *i e*, the vertebral column from the nape of the neck to the sacral area The potential or quantity of current does not provoke pain The reaction subjectively, of the patient is one of formication In certain areas which are insensible to pressure sensations, pain is elicited when the cathode is placed over the area This pain, however, does not register in the galvanometer reading

The area in which pain is elicited follows the distribution of the nerve as manifested by metameric innervation Neri reported many cases in which the test was of great value In many cases, the sensation felt by the patient resembled a sudden sharp bite The zone of hyperalgesia was distinctly limited both superiorly and inferiorly The dermatome which was hyperalgesic corresponded exactly to the specific spinal root This sign was valuable in the differential diagnosis of lesions of the cauda equina from those of the conus Faradic cutaneous hyperesthesia is also of value in the early diagnosis of herniation of intervertebral disks and Pott s disease

Neri waited four years before he published his results correlating the operative and radiographic results with those found by his special method He proved that after the compression was removed, the area of hyperalgesia disappeared

Examination of Cerebrospinal Fluid —Love advises that all patients who are having enough trouble to warrant surgical operations on their backs should undergo lumbar puncture and should have the cerebrospinal fluid examined Protruded disks rarely produce subarachnoid block so that if a block is found other lesions particularly neoplasms immediately come into the differential diagnosis In about two-thirds of the cases of protruded intervertebral disks the protein content will be 40 milligrams or more per 100 cubic centimeters A value for protein in the cerebrospinal fluid of more than 100 milligrams per 100 cubic centimeters usually means that a neoplasm rather than a protruded intervertebral disk is present In the presence of an unusually large protrusion complete subarachnoid block, with a high protein content in the cerebrospinal fluid, may be found In such cases the patient is paralyzed and usually the paralysis was of sudden onset

Spinal Puncture —Spinal puncture may be done at the usual level of L3 and L4 In more than 50 per cent of cases the total protein is elevated In most cases this is said to be due to slowing of the circulation in the region of the disk due to obstruction with a leakage of protein out of the blood vessels In the rare cases where a subarachnoid block or a partial block exists below the level of the herniated disk the elevated protein is due also to the accumulation of metabolic products below the level of the block

If a needle is inserted below the level of the block, a Queckenstedt maneuver will, in these few cases, reveal a complete block.

Lumbar puncture in the hands of the expert is a simple procedure with few hazards except the insidious postspinal headache. At the same time it is a procedure in which each case deserves careful consideration and constant attention to maintain efficient technic.

The most dramatic hazard which may occur as a result of hypotension of cerebrospinal fluid within the spinal portion of the subarachnoid space is the precipitation of a herniation of the medulla into the foramen magnum.

The lumbar puncture findings are helpful in most cases. The examination includes the Dynamics, the Chemistry, and the Cytology. The chief disadvantages of lumbar puncture are: Post puncture headache, leakage, and disk puncture.

Love believes that many useless operations would be avoided and those that are necessary could be carried out more satisfactorily if every surgeon knows:

1. What the value for total protein of the cerebrospinal fluid is,
2. Whether or not he was dealing with one or multiple lesions and
3. The exact location of the lesion.

A value for total protein of 100 mg. per 100 cc. of cerebrospinal fluid is seen rarely in cases of protruded disk. A high protein content usually indicates neoplasm.

In one-third of all Love's disk lesions, there was less than 40 mgm. per cent of protein in the spinal fluid.

The protein level is accepted as evidence of herniation if it is between 40 and 120 mg. per 100 cubic centimeters, but if it is much higher, another explanation for the sciatica should be sought for.

Armstrong reserves lumbar puncture for those patients in whom the disk symptoms are sufficiently atypical to suggest the possibility of the presence of a spinal tumor.

DERMATOMES

The distribution of the sensory dermatomes has been studied by Dejerine, Head, Foerster, and Keegan. They have been determined by differential root section, stimulation of divided posterior roots, chemical irritation of cord segments, after the appearance of herpes zoster, after trauma, and after operative resection of sensory roots involved in neoplastic growth or compressed by a disk fragment. There has been much written about the various dermatome charts. Some prefer Foerster's; others favor Keegan's. It is not so important whose chart is followed, if the diagnostician and surgeon study their cases carefully before, during and after surgery and integrate and correlate all the information gained thereby. Mixter finds that the method used by Foerster of isolation of a single root by rhizotomy of the adjacent caudal and cephalic roots, following the experimental work in monkeys reported by Sherrington, provides the most accurate picture of the lumbosacral dermatomes pertinent to disk surgery.

The sensory overlap of the dermatomes of the fourth and fifth lumbar vertebrae is denied in Keegan's chart, in which that of the fifth lumbar root

is demarcated distally to the second, third, and fourth toes and the dorsum of the foot. Keegan localizes the fourth lumbar dermatome as involving the large toe and dorsum of the foot. He considers this distribution to be characteristic of disk herniation at the third lumbar interspace.

Head plotted his dermatomes chiefly from areas of herpetic eruption. Keegan's are based on definite sensory loss from single nerve-root compression. Foerster used the method of remaining sensation after nerve-root

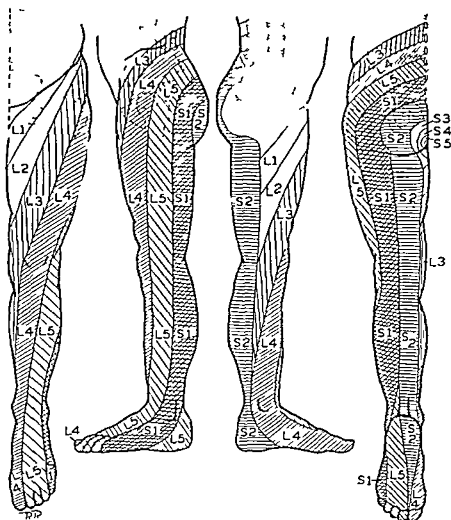


FIG 348 —Dermatome chart of the lower extremity. Composite dermatome chart of the lower extremity determined by hypalgesia from single nerve root loss. (From the original of Figure 9, Keegan and Garrett, courtesy of Anatomical Record 102: 417, 1948.)

section above and below. The neurological signs are not always conclusive as to localization partly because of variation in dermatome distribution.

Spurling finds the dermatomes very helpful in localizing an intraspinal lesion. Lesions involving the 5th lumbar nerve disturb the sensation of the skin over the top of the great toe and a strip up the foot and leg. Lesions involving the 1st sacral nerve, disturb the sensation of the skin over the dorsum of the foot. Lesions involving the 2nd sacral nerve affect the lateral aspect of the leg.

The great toe is an important diagnostic and localizing member. When its sensation is disturbed and the Achilles reflex is abnormal, it is of real diagnostic significance.

L5 nerve irritation indicates a lesion below the 4th lumbar vertebra. S1 nerve irritation means the lesion is below the 5th lumbar vertebra. In the lumbar region herniation compresses the nerve root owing to the obliquity of emerging nerve roots at this level.

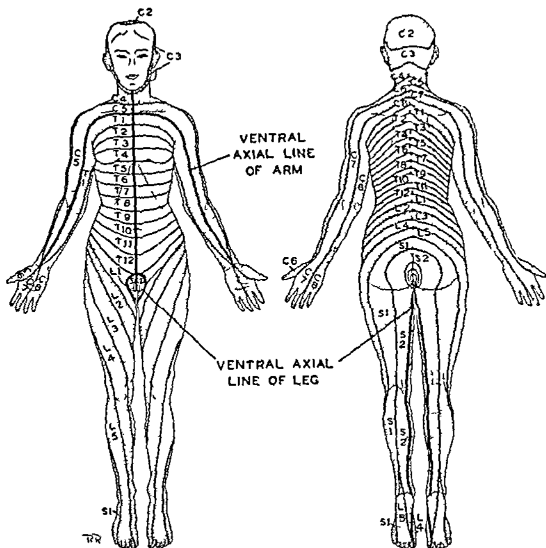


Fig. 349.—Complete dermatome chart of the human body according to *Keegan*. (Arch. Neurol. and Psychiat.)

Keegan's new dermatome charts for the lower and the upper extremities have been combined with the standard dermatomes of the trunk to furnish a new dermatome chart of the human body, which is helpful in neurologic diagnosis and anatomic teaching.

The method of testing for sensory loss is simple. All that is required is a light pin scratch adjusted so that the patient identifies it as sharp but not painful and reports it as definitely *sharper* as the pin passes out of a hypalgesic area into a normal zone.

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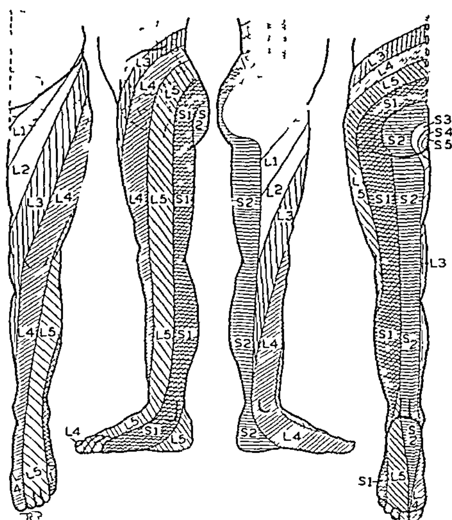


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or last rib Thus, the commonly identified fifth lumbar nerve root with its characteristic dermatome hypalgesia has been found constantly emerging from the spinal canal between the twenty-fourth and the twenty-fifth vertebrae of the total series, regardless of anatomical variation Other nerve roots are found in corresponding positions in the series

Keegan demonstrated a simple dependable method for localization of lesions of an individual nerve root through changes in its sensory distribution He has demonstrated definite areas of reduction of epicritic sensation from loss of function of an individual nerve root in the extremities and from this he presents a new dermatome chart

Keegan emphasizes the importance of exact identification for determination of the position of the involved nerve root He presents a dependable technic for evaluation and accurate localization of compression of nerve roots in certain types of disability of the lower part of the back with pain radiating into one lower extremity

Herniated lumbar intervertebral disks commonly compress single nerve roots, and present associated dermatome hypalgesia in the lower extremity which is accurately diagnostic of the location of the lesion

Keegan s new dermatome chart of the lower extremity is based upon hypalgesia from proved single nerve root loss

Subjective and objective numbness and reflex loss are organic neurological signs, not explainable from any possible reflex reference from obscure distant pathology Numbness over the distribution of a single nerve root dermatome indicates a lesion directly and discretely involving that root

Roentgenograms of the lumbar spine should be directed to the disk indicated by the finding of unilateral single dermatome hypalgesia

Sensory Disturbances in Sciatica Due to Intervertebral Disk Protrusions —Fifth Lumbar and First Sacral Dermatomes —Falconer, Glasgow and Cole find that the sensory disturbances, which occur in sciatica originate in changes affecting a single dermatome and can be explained by the hypothesis that each particular area of skin is innervated from two or more posterior nerve roots These disturbances can only be detected by careful sensory testing They are due to lesions of either the fifth lumbar or the first sacral nerve roots, and conform to a pattern which is characteristic of the particular nerve root

A lesion of either of these nerve roots produces a sensory disturbance *not only* in the leg and foot, but also in the thigh and buttock Sensory impairment in the thigh and buttock in a patient with sciatica can no longer be regarded as evidence that several roots of the cauda equina are involved, or that the patient is hysterical because his sensory pattern does not conform to the classical dermatome charts If in a patient with sciatica, a sensory disturbance can be demonstrated careful plotting of its boundaries will usually identify the affected nerve root

DERMATOMES vs SCLEROTOMES

The clinical symptoms and physical findings should determine which nerve root is exposed to pressure The following outline of Friberg and Hult is helpful in this respect

The segmental distribution of the cutaneous nerves in the limbs of man has been the subject of considerable confusion and uncertainty, due to limitations of technic and lack of well controlled human cases for study Keegan made a new approach to this problem by utilizing the many clinical cases in which herniation of the nucleus pulposus of an intervertebral disk compresses a single nerve root intraspinally and are operated on for relief Surgical demonstration that a discrete nucleus pulposus herniation commonly compresses only one nerve root, and the finding of an area of diminished cutaneous sensitivity for this functional loss has permitted the drawing of new dermatome charts of the limbs of man and these have been combined with standard dermatomes of the trunk to form a new dermatome chart of the human body This chart presents a regular pattern of serial dermatomes in the limbs extending as continuous bands from the dorsal mid line of the body down the arm and the leg

The exact anatomical significance of dermatome areas of primary hyposensitivity from single nerve root loss is somewhat uncertain

The findings of diagnostic areas of sensory reduction or hypalgesia, with loss of a single nerve root has made possible the accurate identification and location of nerve roots in their relation to vertebral sequence and abnormality From Keegan's study it has been found that each nerve root maintains a constant position in the total series of vertebra, regardless of a variable number of ribs or of transitional types of vertebrae This observation has clarified some misinterpretations of anatomic and pathologic variations of the spine not related to symptoms of nerve root involvement *Keegan's thesis is based on careful neurologic observations in a* large series of clinical cases with surgically verified compression, traction, injection or section, of single nerve roots

Discrete postero lateral herniation of the nucleus pulposus of an intervertebral disk compresses only one nerve root Degeneration and separation of the nucleus pulposus of a disk, without extensive degeneration of the annulus fibrosus leads to a posterior shift of the nucleus within the disk, on stooping strain with sudden pain or 'catch' in the back and usually with no symptoms referable to the nerve root at this stage If the nucleus breaks through the posterior longitudinal ligament it usually is to one side of the mid line directly beneath a single nerve root as it leaves the dural canal Direct observation at operation shows only one nerve root flattened over the herniated disk in a position which would make compression possible

Keegan presented a complete dermatome chart of the human body in which the new dermatome patterns of hypalgesia for the upper and the lower extremities are added to the generally accepted dermatome pattern for the trunk The dermatome areas in this new chart are arranged in continuous serial order through the extremities, as in the trunk

This study of the cutaneous distribution of nerve roots to the extremities by outlining single nerve root dermatome hypalgesia with verification by surgical exploration, indicates that there is no change of position of the nerve roots with the addition or reduction of lumbar vertebrae in man if the vertebrae are counted in total numerical sequence, and not by an arbitrary lumbar series defined by the quite variable first sacral segment

CHAPTER 52

X-RAY FINDINGS

THE x-ray may be very helpful or woefully misleading. Routine x-rays reveal a narrowed intervertebral disk space. This indicates either degeneration or protrusion of a disk. It is commonly found in tuberculosis, arthritis and disk lesions.

Disparallelity of vertebral borders is one of the best indicators of mechanical trouble. The "stature" of the disks is indicated by the width of the interspaces. When a disk space is narrower than the one above there *is* or *has been* trouble in the narrower one.

The x-ray findings are often negative or inconclusive. Evidence of disk disturbance consists of narrowed spaces which means either degeneration or displacement. The posterior juncture of L5 to S1 "takes the beating." The increased amount of white indicates bone scars from wear and tear or fusion. The abnormalities delineated in the x-ray may not be the cause of the disorder under investigation.

There is no absolute parallel between the intensity of the subjective symptoms and the roentgen findings. Marked anatomical changes of the disks may be present without roentgenographic visualization. "The local pathology is always worse than the x-ray indicates."

Special X-ray Technics are angulated projections.

The wise surgeon asks himself the questions:

1. Are the findings due to

   New } or } Trouble? Old }

2. If old, what aggravated them?
3. What is wrong besides what I see in the x-ray?

Contrast media often visualize the lesion accurately.

There is no pathognomonic x-ray finding in the disk syndrome but two findings are of confirmatory value. Narrowing of the intervertebral space can be seen both in the antero posterior and lateral views of the spine. It is not a consistent finding nor does it always indicate the presence of a herniated disk. Frequently the loss of the normal lumbar lordosis is evident on x-ray as a poker-straight appearance.

Routine roentgen examination of the lumbar spine with the patient in the recumbent posture does not always reveal the true picture. Roentgenologic examination of the lumbar spine during flexion, extension and lateral bending offers valuable diagnostic information.

In 1944 Knutsson studied the stability of the lumbar spine in disorders of intervertebral disks. He demonstrated that even small and early changes may produce a disturbance of the normal parallelity of vertebral bodies, as

(*a*) *Pressure on the fourth lumbar nerve root* is indicated by
 1 Pain radiating to the hip and the anterior aspect of the thigh but not often below the knee
 2 Absent or weakened knee-jerk
 3 Adductor tenderness in the thigh

The herniation is usually located laterally in the fourth interspace or possibly in the third

(*b*) *Pressure on the fifth lumbar nerve root* is indicated by
 1 Radiating pain to the great toe
 2 No alterations in reflex activity
 3 Paresis in the dorsal extensors of the great toe or the other toes and often in the pronators of the foot
 4 Altered sensibility within the fifth lumbar segment (anterolaterally on the calf, the dorsum of the foot and the great toe)

The herniation is usually situated in the fourth space, or far laterally in the fifth space

(*c*) *Pressure on the first sacral nerve root* is indicated by
 1 Radiating pain to the heel
 2 Absent or weakened ankle-jerk
 3 Paresis of the triceps surae and possibly also atrophy of the calf
 4 Altered sensibility within the first sacral segment (back of the calf, under the heel and lateral part of the foot)

The herniation is usually situated in the fifth interspace

Love advises that all patients who have intractable low-back pain and sciatic pain and all patients with evidence of nerve-root involvement should have roentgenograms of the appropriate portion of the spinal column before surgical intervention is undertaken, no matter how obvious the diagnosis seems to be.

A diagnosis of protruded intervertebral disk should not be made on the basis of a roentgenogram alone, but many other conditions which might produce a similar symptom complex may be excluded, or their presence may first be detected by means of roentgenograms.

shown on films made while the patient was bent forward and backward This is called functional roentgenologic examination

Abnormal mobility between two vertebrae has been observed both at autopsies and during operations Knutsson showed that hypermobility between two lumbar vertebrae could be demonstrated roentgenologically He showed that in bending forward there was anteposition and in bending backwards there was retroposition of the vertebra from the cranial to the caudal ends This abnormal mobility which Friberg and Hirsch called instability of the vertebrae, was observed, both in conjunction with other roentgenological signs of disk degeneration and as an isolated phenomenon When it occurred alone, Knutsson regarded it as an early sign of degeneration of the intervening disk

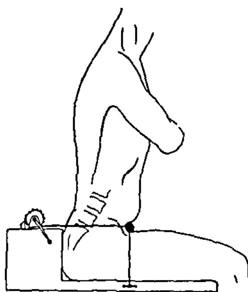


Fig 350 —Method of immobilizing the pelvis for the motion study of the lumbosacral spine (Gianturco courtesy of Am J Roentgen)

Hoen and Duncan De Jeze and Gianturco reported that in some patients with verified disk prolapse, they were able to demonstrate roentgenographically a diminution of angulation between the vertebral bodies

Friberg observed patients with instability who several years earlier had back disorders with negative roentgenograms A few years later this stage of instability passed over to a stage with signs of degeneration When degeneration has progressed and sclerosis of the surfaces of the vertebral bodies with osteophytes has occurred, instability was not often present because, by this time some healing had taken place

Spinograph—Spondylograph—Vertebrograph —Raising the roentgenogram to the dignity of a spinograph will stimulate interest, advance knowledge improve diagnosis and speed up early treatment

A spondylograph reveals the type of back under discussion and the anatomical and pathological variations from the normal I should like to suggest the general use of the term spinagram '

Some diagnosticians and surgeons expect the myelogram to write the diagnosis on the scoreboard This can be accomplished at times at other times it appears to write the wrong diagnosis and at still other times it indicates the correct diagnosis at the wrong location Certain cauda equina tumors are clinically indistinguishable from disk lesions The myelogram is the most valuable aid in the differential diagnosis Those who perform disk surgery, without myelography, must assume a definite risk of overlooking a tumor, both before or during surgery

Intrathecal injection of radiopaque oil may be followed by a mild fever of short duration, less frequently by headache and aggravation of previous symptoms Although the oil slowly becomes fixed in the sheaths of the spinal nerves and the caudal sac, it may produce mild arachnoiditis with fine adhesions between the arachnoid membrane and the dura

There is a wide span of opinion for example one group says "Always do a myelogram" Another group says, "Never do a myelogram" In between these two extremes, will be found the truth—never say "never and never say 'always"

The deformity in the myelogram produced by spondylolisthesis is oftentimes indistinguishable from that produced by a protruded intervertebral disk

Scope of Investigation —One must make a routine study of the entire lumbar and thoracic subarachnoid spaces, at least up to and including the level of the 8th thoracic vertebra, unless a block is demonstrated Myelography is valuable in recognizing a tumor before serious damage to the spinal cord or its nerves has occurred In about 18 per cent of all cases of protruded intervertebral disk, the protrusions are multiple Myelography is a practical method by which they may be diagnosed and localized prior to operation An important aspect of myelography is its value when two lesions are present, regardless of whether they are similar

Myelography in expert hands and when its evidence is interpreted with a full knowledge of the clinical findings, is an indispensable aid in the diagnosis of the great majority of compressive spinal lesions A negative myelogram however, does not rule out the possibility of a ruptured disk Gareau reports 12 per cent negative myelographic examinations

Camp outlines the indications for myelography as follows

1 To determine the presence and type of a lesion when the clinical evidence is uncertain or indefinite

2 To establish the exact level and type of a lesion and to facilitate surgery of limited extent

3 To exclude the possibility of multiple lesions

4 To determine the cause of recurrent symptoms in patients who have had a previous operation

5 To establish the presence or absence of lesions, in medico-legal cases

Camp offers the following suggestions for the use of contrast myelographic media

1 For a study of the lumbar canal and the recognition of a suspected protruded lumbar intervertebral disk air myelography provided one is fortified with enough experience and confidence to interpret the results otherwise, pantopaque myelography

CHAPTER 53

MYELOGRAPHY

Myelography is the science of visualization of the subarachnoid space by means of the roentgen ray. This is accomplished by the injection of radiopaque substances or gases that delineate defects caused by space-occupying objects. Abnormal defects or shadows are interpreted on the basis of clinical and surgical experience. There is a controversial halo around this diagnostic modality.

In regard to a myelogram: One should ask himself the questions:

Is it always necessary?

Is it ever necessary?

Is it necessary in the case at hand?

Is it worth the effort and the disadvantage?

The spinal canal is a tube-like structure formed by the dura mater with its inner lining of closely adherent arachnoid. The subarachnoid space, is not a void, because passing through the greater part of its length is the spinal cord closely invested by pia mater, forming a central core, which converts the canal into a shallow water jacket (Reid).

The spinal cord and its nerves are *suspended in the cerebrospinal fluid*, by means of nerve roots and ligamenta denticulata.

In 1919 Dandy introduced air into the spinal canal. In 1922 Sicard and Forestier introduced lipiodol. Chamberlain employed oxygen or air. Spurling introduced pantopaque. Diskography is too new to be discussed or evaluated by many experts.

Some authorities advise myelography in every case; others never prescribe it. Myelography may be indicated:

1. *To localize a lesion.*
2. To visualize or exclude multiple lesions.
3. To determine the extent of a space-occupying lesion.
4. To visualize intra- or extramedullary pathology.

Myelography helps to establish the presence of a tumor and its exact site. The column of iodized oil is characterized by pairs of axillary pouches which mark the points at which nerves leave the dural canal. The term "axillary pouch" was applied by Barr, Hampton and Mixter to the little intradural sac formed by the arachnoid.

The main purposes of a spinogram are to localize the level of a ruptured disk, to determine the presence or absence of multiple disks and to rule out intradural lesions, especially tumors. A spinogram is desirable when a supplementary spinal fusion is contemplated. It would be better if myelography were never done, unless one plans and is prepared to proceed with surgery, if the test should indicate that exploration is advisable. Myelography should be comformatory as well as confirmatory.

The most satisfactory method is to introduce radiopaque oil into the subarachnoid space. Love considers this method as the most nearly accurate. In experienced hands, few protruded intervertebral disks should be missed and false positives should be infrequent. In 34 cases there were major discrepancies. The myelogram was negative in 24 cases in which a bulging, protruded, or extruded disk was found. In 10 cases where myelogram defects were seen at L4 no ruptured disks were found at L4 but were present at the lumbosacral area.

In spite of the fact that the myelogram is diagnostically accurate in only 7 cases out of 10, Key and Ford continue to use it often because it may be 60 per cent accurate in the group of cases in which other measures are inconclusive, thus raising the over-all percentage of accuracy. However, when symptoms and findings indicate, a negative myelogram does not deter their recommending or carrying out operative treatment.

Harmon obtains valuable information from spinograms even though the findings are indecisive in about 25 per cent of the cases. Removal of the medium reduces the number and severity of complications.

Only 80 to 85 per cent of the disk protrusions or bulges found at operation are demonstrable in preoperative myelograms. Conversely, false positives are occasionally seen in myelography. Harmon does not perform myelography except to determine the diagnosis in disputed cases, including medico-legal and compensation cases, or as a process for localization of disk protrusions prior to operation.

Spinal myelography is a requirement in cases of six lumbar vertebrae and other transitional osseous configurations, including spondylolisthesis, to localize a protrusion accurately.

O'Connell regards myelography and routine lumbar puncture as unnecessary. Barr employs myelography in every case in which surgery is contemplated and in which other studies have failed to produce an unequivocal diagnosis. Harmon feels that in the borderline type of patient, especially in the compensable group, reliance on the oil study will result in fewer negative explorations than if one depends entirely on the clinical findings.

A surgeon may be confronted with neurologic borderline patients who have already been examined in several clinics, patients with litigation pending, or Industrial Commission cases in which it is impossible to gauge objectively the degree of subjective pain of which the patient complains. It is especially in these latter cases, in which the surgeon wishes to avoid a negative exploration, that Meredith utilizes the pantopaque study. Some insurance companies and their medical directors insist on reviewing the pantopaque films in the home office before authorizing surgical removal of a suspected protruded disk.

Myelograms are usually made after the diagnosis of a protruded disk has been made in order to localize the lesion. Friberg and Hult report 22 patients with positive myelograms who were not operated on. They were examined one to three years later and found to be back at work, some of them entirely free from symptoms.

The advantages of air are that it is not irritating and leaves no residue on which lawyers can base medico-legal claims.

2 For a study of the thoracic vertebral canal and for the recognition of a suspected tumor of the spinal cord in any region, lipiodol myelography

3 For the recognition of protruded cervical intervertebral disks pantopaque or lipiodol myelography

Barr finds that modern myelographic technic in which the pantopaque is removed immediately upon conclusion of the examination, is safe and not particularly difficult It often yields most important information not obtainable by clinical examination

Key and Ford consider that a myelogram is indicated when six lumbar vertebrae are present or when a sacralized lower lumbar vertebra is present It is also wise in cases in which litigation is involved, to do myelograms so that objective evidence of the condition may be at hand

While a positive myelogram is usually good evidence of a disk rupture, a negative myelogram does not necessarily exclude the presence of such a rupture

Technic of Myelography (Key and Ford) — The patient should be premedicated with three grains of nembutal and one-sixth or one-quarter grain of morphine an hour before the procedure

A tray consisting of pantopaque, a 20-gauge spinal needle novocaine, suitable syringes (2, 5, and 10 cc sizes), and a skin antiseptic, is used Key has the patient sit on the side of the *x*-ray table and lean forward This makes it easier to do the lumbar puncture Straightening the spine helps to make a more accurate puncture The plain *x*-ray should be checked just before the lumbar puncture so as to place the needle in the third lumbar space This space is infiltrated with novocaine in the skin and into the supra- and interspinous ligament The needle is now inserted in the midline When the needle is in the subarachnoid space, the patient is gently assisted onto his side, keeping his hips and knees flexed

The needle is covered with a sterile sponge a suitable lead marker is taped to his back and fluoroscopy is begun A tilt top table with a device for taking spot films is essential The patient is rolled onto each hip to allow oblique as well as AP views If a midline disk is suspected, prone lateral views may be made

After films are taken the fluoroscope is used to pool the media evenly around the tip of the needle The needle is then uncovered, a syringe is attached and the needle is pushed forward to the anterior dura Then the media is aspirated The needle is rotated 90° to 180° in either direction so as to avoid suction of nerve roots With care, it is possible to withdraw 90 per cent or more of the media

Two points in the technic of myelography are stressed by Barr There is danger of the needle slipping out of the canal or of its injuring nerve roots if the puncture is done while the patient is in the sitting position and is then moved to the recumbent position The lumbar puncture and the injection of pantopaque should be done with the patient lying face downward on the fluoroscopic table The proper interspace can be identified by fluoroscopy, if desired A pillow under the abdomen will separate the spinous processes and make the patient comfortable

Barr finds that if removal of pantopaque is painful, it means that a nerve root is being sucked against the needle The aspiration should be done very slowly, and if pain occurs the needle should be rotated 90°

9. Always inject a test drop which must move freely. Inject 6 to 9 cc or even 12 cc.
10. Then fluoroscope.
11. Do not do a myelogram too soon after a lumbar puncture.
12. Fragmentation of column into droplets destroys the value of the test.
13. Explore from the foramen magnum to sacrum.
14. Puncture of a disk causes pantopaque deformity and pain.

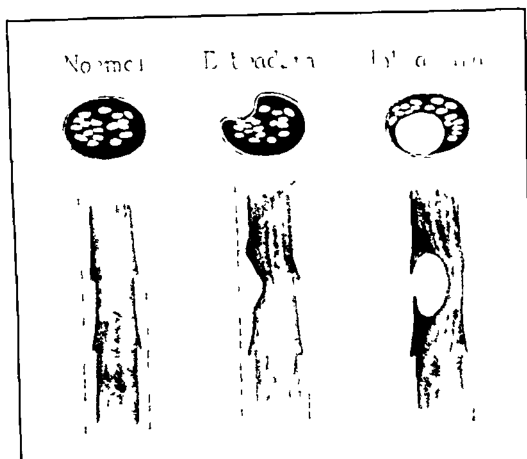


Fig. 352.—Sketch depicting characteristic shadow produced by radiopaque oil in the subarachnoid space in a normal sector of the cauda equina and characteristic defects in the shadow of the radiopaque medium produced by extradural and intradural tumors affecting the cauda equina. The radiopaque medium within the subarachnoid space is indicated in the drawing in black. (Camp: courtesy of Radiology.)

A routine test requires thirty to thirty-five minutes. Use a 19 gauge needle with a long sharp bevel. Do not use a grid. Use a narrow field.

Falconer, McGeorge and Begg found that routine myelography performed in patients suffering from sciatica or low back pain, admitted to hospital because of severity or intractability of symptoms, indicated that intraspinal lumbar disk protrusions were present in almost every case.

Myelography, when repeated after spontaneous recovery from symptoms had occurred, usually showed that the intraspinal disk prolapse persisted apparently unchanged.

Friberg and Hult used abrodil in a 20 per cent solution in myelography. Abrodil is soluble in water and mixes with spinal fluid in all proportions, thus visualizing nerve roots and root pockets. It is quickly absorbed and disappears from the fluid within thirty minutes. The acute irritation caused by abrodil is eliminated by concurrent lumbar anesthesia. The method was described by Lindblom.



Fig 351.—*A*, A P projection showing typical defect in radiopaque column in spinal canal due to a protruded intervertebral disk below 4th lumbar vertebra. *B*, Lateral projection showing typical defect in radiopaque column in spinal canal due to protruded intervertebral disk below 4th lumbar vertebra. (Courtesy Percy Jones General Hospital X Ray Dept.)

Peterson makes the following observations and advises the following:

1. Insert the needle in the midline below L3.
2. The next best point of entry is below L2.
3. Avoid puncturing a disk.
4. Avoid proximity to a disk.
5. Avoid puncturing any pathological lesion.
6. Go midway below pedicles.
7. You must be in the subarachnoid space, not the subdural space.
8. If the needle is subdural, evacuate immediately.

sac in thin people is common. *If oil gets into the roots, it is unfavorable.* Multiple myelographic deformities are more common than multiple disks.

In a complete block the wider subarachnoid space above the site of the block is on the same side as a tumor. At the level of the block, any prolongation of the subarachnoid space is probably on the side of the cord opposite a tumor. Neat filling defects on myelographs are seen only in early cases of tumor compression.

In interpreting the films Spiegel looks for true defects in the column of pantopaque rather than the long smooth defects which are most frequently artefacts. *A swollen nerve root may also cause a defect in the column of oil.* It may be visualized as an hourglass deformity, though this deformity

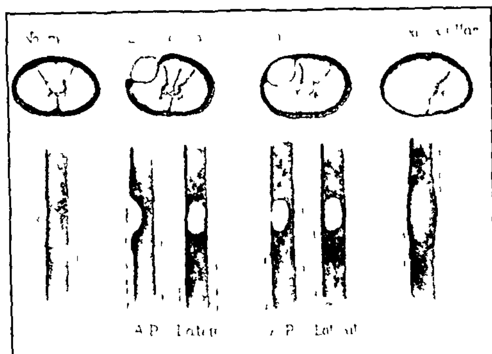


FIG 354 —Drawing depicting the characteristic shadow produced by a radiopaque medium in the subarachnoid space in a sector of normal spinal cord and the deformity produced in the shadow of the radiopaque medium by extradural, intradural and intramedullary tumors. The radiopaque medium within the subarachnoid space is indicated in the drawing in black. (Camp, courtesy of Radiology.)

may be due to a central protrusion of a disk. In the more laterally placed herniation there may be no defect in the column of oil, but the dural sleeve around the nerve root may be obliterated. The subarachnoid space normally ends in the upper portion of the sacrum. This sac may be foreshortened and appear to end higher. A congenitally narrow spinal canal may be observed or simulated.

False positives occasionally occur. Barr saw a large constant filling defect involving over half the width of the dural sac, with an absolutely negative exploration. Congenital arachnoid bands may account for some of these cases. When operation has been decided upon and the myelogram is negative, *the lumbosacral space should be explored first.* Meredith found that false negative and false positive readings are encountered in the interpretation of the fluoroscopy and the films.

Armstrong considers myelography to be the most valuable measure in the localization and diagnosis of spinal tumors and of conditions in which the spinal theca is compressed and encroached upon However, he considers the value of myelography in the diagnosis and localization of lesions of the lower lumbar disks to be doubtful He finds that a myelogram is an uncertain and unreliable method of demonstrating the presence of a lesion of a lower lumbar disk and that many such lesions cannot possibly be detected by myelography



Fig 353 —Multiple protruded intervertebral disks Typical deformity of lipiodol shadow caused by protrusion of the disk between the third and fourth and between the fourth and fifth lumbar vertebræ (Camp courtesy of Radiology)

Armstrong considers that myelography has certain disadvantages and dangers besides being unpleasant for the patient cumbersome and time consuming He reserves myelography for those patients in whom the presence of a spinal tumor is suspected He considers that it is contraindicated in all other patients

Interpretation —There are normal variations Too little oil tends to produce misleading films Never make a diagnosis on the basis of an intradural injection Not all apparent short sacs are really short A wide

sac in thin people is common If oil gets into the roots it is unfavorable Multiple myelographic deformities are more common than multiple disks

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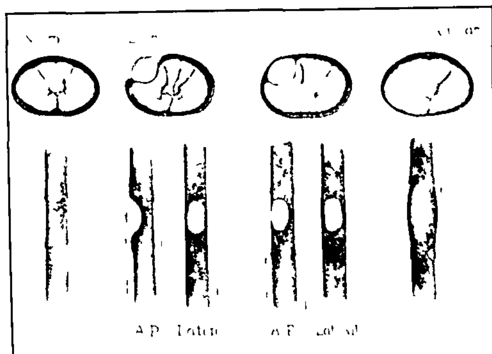


Fig 384 —Drawing depicting the characteristic shadow produced by a radiopaque medium in the subarachnoid space in a sector of normal spinal cord and the deformity produced in the shadow of the radiopaque medium by extradural intradural and intramedullary tumor The radiopaque medium within the subarachnoid space is indicated in the drawing in black (Camp courtesy of Radiology)

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The verified diagnostic accuracy of myelography has been reported by various authors as between 67 and 96 per cent. Key and Ford report 72 per cent of accuracy. False impressions may be created by myelography. Root sleeve shadows are commonly seen. Needle tract distortions may be misleading.

DISKOGRAPHY—NUCLEOGRAPHY—THE DIRECT ROENTGEN RAY VISUALIZATION OF INTERVERTEBRAL DISKS

One of the most important additions to our armamentarium in the diagnosis and, therefore, treatment of the ruptured lumbar intervertebral disk is the new diagnostic procedure known as diskography (Cloward).

Diskography was introduced by Lindblom, in 1948, who conceived the idea of visualizing the intervertebral disk itself by a direct puncture of a disk and injection of a contrast material within the disk substance. Injecting a 35 per cent solution of diodrast through a long very fine spinal puncture needle, the nucleus pulposus is beautifully demonstrated on the x-ray. In a normal intervertebral disk only the nucleus pulposus is stained by the dye. If the fibers of the annulus fibrosus are ruptured and a collapse of the nucleus results in disorganization and degeneration of the disk, the entire intervertebral space will be filled with diodrast.

Erlacher employs a direct contrast method by injecting the nucleus pulposus. Nucleography is carried out as follows: After filling the syringe with 2 to 3 cc. of 50 per cent aqueous iodine solution the needle is withdrawn and x-rays are taken. The entire nucleus pulposus and all traumatic changes can be visualized.

Diskography outlines the pathologic process directly instead of indirectly, as in myelography. It is a positive rather than a negative measure. Diskography should never be undertaken without previous examination of the spinal fluid which will disclose the presence of most of the cases of tumor.

Hirsch carried out some interesting and instructive work on transdural puncture. He injected either (1) normal saline under pressure 0.5 to 1 cc. or (2) contrast perabrodil and novocaine or (3) novocaine alone 0.5 to 1 cc. of 1 per cent. He believes that pain on increasing pressure indicates disk degeneration (rupture of annulus fibrosus).

In 16 cases of relapsing low back pain, a transdural puncture of one or both of the two lowest lumbar disks produced pain identical with the patient's spontaneous pain. Pain occurred either at the moment of puncture or when the intra-diskal pressure was increased by introducing normal saline under pressure. It rapidly disappeared and the Lasègue sign was either markedly reduced or abolished with the injection of ½ cc. of 1 per cent novocaine into the disk.

In 1948 Hirsch published a report of his experiences with disk puncture. Under x-ray control a fine needle was inserted transdurally in two or three lumbar disks and normal saline solution was injected under pressure. With a normal disk it was possible to introduce a few cubic centimeters even when the pressure was raised considerably. Nothing happened. In a degenerated disk up to 1 or 2 cc. could be injected. So long as the pressure was low the patient noticed nothing but if the pressure was raised during

the injection the patient suffered violent pain which he could clearly identify as the pain of an attack of lumbago When the pressure in the syringe was allowed to fall the pain disappeared It was the pressure alone that determined the severity of the pain If the saline injections were preceded by the injection of 0 5 to 1 cc of 1 per cent novocaine no pain appeared These observations were interpreted by Hirsch as indicating that intradiskal pressure above a certain level causes an attack of lumbago probably by way of the posterior longitudinal ligament Anesthesia of the posterior region of the disk will block the nerve endings of the posterior ligament and preclude the appearance of pain The posterior longitudinal ligament might be considered a pressure recording structure which upon irritation above a certain level, gives rise to lumbago

DIAGNOSIS OF LEVEL OF A DISK LESION BY MEANS OF DISK PUNCTURE

Hirsch believes it is possible to determine which disk is causing the pain

Procedure and Technic — The patient is placed in the lateral horizontal position as for lumbar puncture and a 20-gauge needle is introduced into the subarachnoid space at the desired level After obtaining cerebrospinal fluid the needle is advanced into the disk space and the position checked by fluoroscopy and spot roentgenograms A syringe containing normal saline solution is then attached to the spinal needle and injection is attempted In patients with degenerated disks from 3 to 10 cc of saline solution can be injected into the disk with relative ease

It is important to inject the dye into the posterior portion of the annulus The usual myelogram may fail to show the presence of a protruded disk The operative procedure should be postponed for a few days following the test

Hoen found that degenerated disks would accept by direct injection quantities of normal saline solutions whereas it is not possible to inject a normal intervertebral disk Furthermore, a disk extrusion which leaves a defect in the ligamentous structures may receive unlimited quantities of the solution According to Hoen and associates preoperative injection of lumbar intervertebral disk is a useful measure in revealing lumbar disk changes in patients with low back pain unaccompanied by sciatica

A modified Lindblom s method of direct injection of radiopaque material into intervertebral disks was used by Gardner Wise and Hughes in 89 patients They describe a normal disk which usually exhibits a bilocular collection of dye which occupies approximately the middle third of the disk in both lateral and anteroposterior projections Injection of a normal disk is made against great resistance it is usually painless but mild local back pain may result No radiating pain down the leg is produced

A second type of picture described by Lindblom is a "degenerative type of nucleus is frequently seen The dye shadow is not discrete and bilocular, but is spread irregularly throughout almost the entire disk and may extend slightly beyond the margins of the bodies of the vertebre

The third or symptomatic type is the degenerated disk with posterior protrusion This usually reveals a picture similar to the above type plus

the presence of dye beneath the posterior spinal ligament, which is seen to bulge into the lumen of the spinal canal

Gardner and associates found that by the injection of diodrast, it was possible in a high percentage of cases to differentiate between a normal disk, a degenerated disk, and a degenerated disk with posterior protrusion The normal disk was usually characterized by a pooling of the diodrast in the spaces above and below the intact nucleus producing a bilocular shadow In the protruded disk this bilocular shadow was seldom present Reproduction of sciatic pain during the injection occurred in two thirds of the cases of proved protrusion This sign should not be relied on unless accompanied by roentgenographic visualization of a protrusion of the disk In approximately one-third of the cases of surgically proved protruded intervertebral disk some of the injected dye was visible in the epidural space on the roentgenograms The presence of dye in the epidural space is significant only when accompanied by roentgenographic evidence of protrusion

Gardner feels that this procedure has the following disadvantages

1 It is not free of morbidity

2 Considerable care and experience are necessary in accomplishing the injection and in interpreting the results

3 It may result in overlooking a tumor of the cauda equina which would have been disclosed by myelography

Cloward considers the work of Gardner and his associates, on diskography to be the most important advance in the treatment of ruptured disks

A large percentage of patients with a disk syndrome with herniation of disk and clinical evidence of compression of a nerve root will have positive myelograms

It is in the cases in which there is no sciatica but disabling back pain that Cloward would like to know if the pain is due to a ruptured disk

There are many cases of disabling recurrent backache in which there are no objective signs The patients go on month after month and year after year laying off from work and being paid for disability, and the surgeon is expected to find out what is wrong with them and what can be done

With the diskogram, even though the disk has not herniated into the spinal canal one can demonstrate that the nucleus pulposus has been ruptured the disk has been broken and the patient has a loose unstable vertebral joint which can be treated surgically

At times one may visualize a balloon like protrusion of the anterior longitudinal ligament into the abdominal cavity The goose bill spurs which one sees in the spine in arthritis may be due to collapsed disks

Hoen, Druckmiller and Cook using a radiopaque medium found that not only could the patient s pain be duplicated but the herniation could be seen in an x-ray

A method of diskography utilizing puncture of the disk in the mid line posteriorly was described by Lindblom in 1948 and he has subsequently reported additional experiences This technic may be used for the three lower lumbar spaces Cloward s work is based on its use Erlacher has independently developed a method utilizing a postero lateral disk puncture

in which the needle does not enter the subarachnoid space. This procedure may be performed at any level, including the cervical region, but is somewhat more difficult than Lindblom's method.

Cloward believes that diskography is of greater value than myelography. He has frequently employed 70 per cent diodrast as a radiopaque medium. It has been his practice to test the pressure and dynamics and collect a sample of spinal fluid while waiting for the first check *x*-ray film.

Interpretation.—Cloward concurs with Lindblom that two factors are necessary for the diagnosis of a ruptured disk by this technic. First, injection should reproduce the patient's symptoms of nerve root pressure. Secondly, the lateral *x*-ray should show a posterior extension of the dye. A positive *x*-ray may show a bulge of opaque material posteriorly or a leak of dye into the epidural or perineural spaces. In the cases with a bulging disk but an intact posterior longitudinal ligament, the injection is usually extremely painful and often only one-half cubic centimeter of diodrast can be injected. The injection of these, as well as normal disks, requires considerable force. With complete rupture of the posterior longitudinal ligament there is less pain on injection of the disk and little or no resistance is felt.

For the diagnosis of space-displacing lesions in the spinal canal, such as nerve root or spinal cord tumors, myelography should be used. In the verification and localization of disk pathology, it is Cloward's feeling that diskography is more direct and far superior to myelography. The accuracy of myelography in the diagnosis of herniated disk is reported to be about 60 to 90 per cent. In Cloward's cases the operative findings have coincided with the diskogram in all cases.

Indications and Contraindications.—Diskography is reserved by Cloward for those patients in whom a ruptured disk is strongly suspected from the history of back injury followed by repeated attacks of disabling low back pain. If the patient has pain in one or both lower extremities along the distribution of the sciatic nerve and has neurological signs of nerve root compression, Cloward prefers to localize the level of the ruptured disk by myelography. These symptoms indicate a protrusion or herniation of the ruptured disk into the spinal canal which can be visualized by an intraspinal opaque medium. If the myelogram in such a case appears normal, diskography is then performed.

The indications for and the chief value of diskography lie in the ability to recognize the presence of a ruptured disk as a cause of the patient's complaints of back pain following trauma without herniation of the disk into the spinal canal and without pressure on nerve roots. In addition to the patient's history, roentgen evidence of changes in the vertebrae at the level of the suspected lesion is also an indication for diskography. If the intervertebral space is narrowed with or without an associated localized chronic hypertrophic spondylo-osteitis (marginal spur formation), a suspected rupture of the disk can be verified by this procedure.

Cloward has found that a true lateral roentgenogram of the lumbosacral spine can be obtained by placing a large noncompressible, non-opaque pad under the lower costal margin, which elevates the thoracic cage level with the hip, and positions the lumbar spine parallel with the table top.

If the disk is ruptured or degenerated, 2 to 5 cc of diodrast can be injected, with ease, requiring little pressure on the syringe The patient may not complain of pain with an abnormal disk until 3 to 5 cc have been injected

Diskography has demonstrated information about the physiology of the intervertebral disk which was previously not known

The diskogram reveals that a disk may rupture in a single or in multiple directions, namely anteriorly, posteriorly, postero-laterally and/or vertically The posterior tear is most common

Posterolateral extrusion of the contrast material is observed when a disk syndrome includes sciatic pain Anterior herniations of a disk with or without rupture of the posterior fibers of the annulus A degenerated disk is evident in routine roentgenograms of the spine

The presence of a Schmorl nodule in the lower lumbar vertebrae, whether demonstrated by routine roentgenograms of the spine or diskogram, indicates a loss of the supporting structure of the nucleus pulposus, and may be interpreted as a vertically ruptured disk producing low back pain Schmorl nodules in the upper lumbar and thoracic vertebrae are usually asymptomatic

Cloward believes that preoperative diskographic demonstration of pathologic conditions of the lumbar disk will revolutionize our criteria and methods of treatment for these lesions, it also seems reasonable to assume that one may anticipate a marked improvement in the end results of surgical treatment

CHAPTER 54

THE DIAGNOSIS OF A PROTRUDED INTERVERTEBRAL DISK

The diagnosis of a ruptured disk and its location can usually be made from the history and physical examination A lumbar puncture is not always necessary, but it is usually enlightening The most important diagnostic question is "Whether one is dealing with a disk syndrome?" The second question is "Where is the trouble located?"

The diagnosis can usually be established beyond a reasonable doubt by the following

1 History of symptoms	4 Routine x-rays
2 Routine examination	5 Special x-ray studies
3 Neurologic examination	6 Lumbar puncture

The most significant points in the history are

1 Recurrent attacks of pain	5 Relief by bed rest
2 Radiation of pain	6 Body list
3 Aggravation of pain by coughing, sneezing or defecation	7 Paresthesias
4 Cause—trauma	8 Muscle weakness

A careful history of the patient's disability is oftentimes sufficient to make a presumptive diagnosis The onset of trouble most often dates back to an injury to the lower part of the back Love emphasizes the fact that the injury may be trivial, and often the patient may not have reported it to his foreman or insurance company Subsequently, with or without further undue stress or strain to the back, recurrent attacks of disabling backache occur, followed by extension of pain to the gluteal region and downward along the course of the sciatic nerve Rest in bed will often relieve it, but about a fourth of the patients have pain at night which awakens them from sleep and causes them to sit up or to walk the floor, to obtain any relief

If the fragmented protruding disk remains in the mid line and does not involve the nerve roots going to the lower extremities Love finds there may be no sciatic pain or scoliosis If the fragment of disk is small and shifts from side to side under the firm mid-portion of the posterior longitudinal ligament, there may be alternating scoliosis without sciatic pain If the patient is asked to bend forward from his hips with his knees straight the spinal column goes through a corkscrew type of motion

The symptoms of the *episodic type of pain* are unique. Any pain in the back that comes on in acute attacks, makes Ivins suspect an intraspinal cause, most commonly a protruded intervertebral disk. Coughing, sneezing, blowing the nose or any strain, accentuate the pain. Ivins finds that pain in the leg may vary from a simple overflow of localized low back pain into the buttock to severe root pain that extends all the way down a leg into the toes. There may be alterations in sensation and paresthesias at times. Rarely, there is some weakness or paralysis of peripheral muscles.

R. H. Young found that severe back pain without sciatica was usually due to a mid line protrusion. If it were very large, the patient had bilateral sciatica.

There are cases where a congenitally defective 5th lumbar vertebra, with or without spondylolisthesis, may closely simulate a disk lesion or may be part of a disk syndrome.

The patient is subject to repeated attacks following slight strains on the spinal column—such as lifting, bending, twisting or slipping. This is one of the most common ailments and one of the most debilitating. However, it is one of the easiest to diagnose and to cure. There are few cases of sciatica with low backache that are not due to defective disks. Dandy considered the combination of a low backache plus sciatica intensified by coughing and sneezing as pathognomonic of a defective lumbar disk.

The symptoms and signs which are most helpful in the diagnosis of protrusion of a lumbar disk are:

- Backache
- Sciatica
- Paresthesia
- Flat back
- Spasm of lumbar muscles
- Limitation of back movements
- Scoliosis
- Lasegue test
- Absent Achilles reflex
- Absent knee jerk
- Tenderness to compression
- Tenderness to percussion
- Naffziger test
- Hypalgesia
- Weakness of muscles
- Atrophy of muscles
- Narrowed disk space
- Spinal fluid findings
- Myelography

RELATIVE VALUES OF SYMPTOMS, SIGNS AND TESTS IN DIAGNOSIS

1. Pain: Back, Leg, Buttock	Lasegue test
2. Deformity—flat back	Achilles reflex change
3. Spastic muscles	Knee jerk change
4. Disability—stiffness, tenderness	Naffziger test
	Atrophy
	Big toe extensor weakness
	Myelography

Sheet Anchors of Diagnosis of Disk Lesions

1. The History
   - *a* Discomfort. Backache and radiation pain
   - *b* Deformity—scoliosis, flat back
   - *c* Disability
2. The Physical Examination
3. The Neurological Examination
   - *a* Diminished or absent patellar or Achilles reflexes
   - *b* Naffziger test
   - *c* Hypalgesia
   - *d* Diminished muscle power
4. X-ray Studies
   - *a* The narrowed intervertebral space
5. Laboratory Studies
6. Cerebrospinal Fluid Examination
   - *a* Disturbed dynamics
   - *b* Chemistry: protein between 40 and 100 mgm. per 100 cc.
7. Myelographic Studies
8. Diskographic Studies
9. Therapeutic Test of Treatment

Most errors in diagnoses are due to:

1. Impatience in obtaining a full history
2. Incomplete physical and neurological examination
3. Failure to make spinal fluid tests
4. Failure to make myelographic studies
5. Failure to obtain neurological consultation

Diagnostic Components.—One asks himself the following questions: (1) Are the symptoms and signs compatible with the presence of a disk? (2) Is the differential diagnosis clear? (3) What is the location of the lesion?

Important Points.—The most important questions from a practical point of view are: (1) Am I dealing with a disk or a tumor? (2) Are more than one disk in trouble? One must always try to evaluate the relative importance of findings that are undoubtedly old, especially deformations of shape and structure due to previous injuries, infections or arthritis.

Routine Examination.—Limitation of forward flexion of the head and back. Limitation of extension of the back. Limitation of rotation of the torso on the pelvis.

Facility in squatting

Palpation Percussion

Special Tests—Lasègue, Naffziger

The Significance of the Flat Back.—Charnley believes that flattening of the lumbar spine or lumbar kyphosis with sciatica is not a reflex mechanism to reduce tension or pressure on the nerve root but is a primary deformity of the lumbar spine resulting directly from altered disk mechanics.

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The symptoms and signs which are most helpful in the diagnosis of protrusion of a lumbar disk are

Backache	Tenderness to compression
Sciatica	Tenderness to percussion
Paresthesia	Naffziger test
Flat back	Hypalgesia
Spasm of lumbar muscles	Weakness of muscles
Limitation of back movements	Atrophy of muscles
Scoliosis	Narrowed disk space
Lasegue test	Spinal fluid findings
Absent Achilles reflex	Myelography
Absent knee jerk	

RELATIVE VALUES OF SYMPTOMS SIGNS AND TESTS IN DIAGNOSIS

1 Pain { Back, Leg, Buttock	Lasegue test
	Achilles reflex change
	Knee jerk change
2 Deformity—flat back	Naffziger test
3 Spastic muscles	Atrophy
4 Disability—stiffness	Big toe extensor weakness
tenderness	Myelography

times one must say to himself "I am not positive what the diagnosis is but I am reasonably sure of certain conditions that it is *not*." To be *positive* is to be *wrong* at the top of your voice.

By means of detailed studies of many patients the neurologist, orthopedist, roentgenologist and neurosurgeon have come to recognize a protruded disk syndrome usually without difficulty. The accuracy of diagnosis which is based on the history and clinical and roentgenologic findings is extremely high. Diagnostic intuition based on a large experience is a great asset but it must be confirmed in every case.

A presumptive diagnosis can often be made from the history alone. The diagnosis of a protruded intervertebral disk can usually be made on the clinical findings alone.

The diagnosis may be suspicious, presumptive, probable or positive. In experienced hands the percentage of error in diagnosis of the presence of a protruded intervertebral disk and its location is very small. In addition to a careful orthopedic and neurological examination, the diagnostic study includes special tests, *x*-ray studies and consultation with other specialists.

The diagnosis depends on the history, physical examination, back signs, straight leg raising test, neurological signs including the Naffziger test, *x*-rays and spinal fluid studies. The syndrome of herniation of a nucleus pulposus may vary extensively, depending upon the size and location of the lesion and the presence of multiple lesions.

I often ask myself "Can one be positive in making the diagnosis of a protruded intervertebral disk?" The answer is "not until one actually visualizes the lesion at operation." No one piece of evidence is decisive. One should always keep in mind a spinal cord tumor masking or simulating a protruded disk. Five per cent of all suspected disk cases have an intraspinal tumor. After all is said and done *Seeing and Only Seeing is Believing*.

One asks himself the question: Is the specific test significant? (1) Alone? or (2) in combination with other observations?

Is it reliable? Is it compatible? Does it conform to the pattern of the history and physical examination? Does it confirm the suspicion aroused by the history and physical examination? Is it indispensable in making a diagnosis?

Many authorities consider the straight leg raising test the most important clinical test in the diagnosis of lumbar disk lesions. A diagnostic suspicion by exclusion or elimination is made upon failure to account for the symptoms, signs and findings on any basis other than a disk lesion.

Questions the Examiner Asks Himself. 1. Is it a disk lesion?
2. Which of the 23 disks is in trouble and causing trouble?
3. Is the disk protruding? Has it protruded?
4. Are there multiple disk lesions?
5. Is there any other lesion or mechanical defect present?
6. What should be done?
7. Is it an "operative" disk?
8. What area should be explored?

Briefly stated Dandy made a diagnosis on the basis of: (*a*) a history of a back injury, (*b*) sciatic pain, usually intermittent, (*c*) exaggeration of symptoms on coughing or sneezing, (*d*) diminution of ankle jerk,

Tests with Eponyms

- Goldthwait
- Lasègue
- Gaenslen
- Ober
- Ely—Nachlas
- Steindler
- Naffziger
- Queckenstedt Test
- Reversed Queckenstedt Test
- Schlesinger Test
- Hirsch Test
- Lindblom Test
- Horn Test
- Gardner Test
- Cloward Test
- Lewin Punch Test*
- Lewin Snuff Test
- Suspension Test

Dermatome determination (hypalgesia), normal prostate examination, normal female pelvis examination

At the Mayo Clinic the chief signs and symptoms are listed as

- Unilateral sciatic pain
- Bilateral sciatic pain
- Low-back pain
- Nocturnal pain
- Sphincteric incontinence
- Lasègue's sign present
- Achilles reflex diminished or absent
- Hamstring reflexes diminished or absent
- Muscle paresis
- Muscle atrophy
- Sensory loss

Correlation of the Signs and Symptoms and Physical Examination in Disk Lesions — The history physical findings, *x*-ray studies and myelographic evidence must conform in order to confirm the diagnosis Burns and Young find that the size of the protrusion varies directly with the restriction to straight leg raising If exacerbation of pain occurs when the normally raised straight leg is allowed to drop, O Connell attaches considerable importance I have used this test routinely over a period of thirty years (I described it in the first edition of this book)

A mid line protrusion may cause uncomplicated backache Hyperextension of the back may nip the protruded portion of a disk thereby aggravating the pain *A positive roentgen film may aid little in localization* and a negative film may be inconclusive

The diagnosis of an intervertebral disk lesion should be considered as a "working diagnosis 'The physician who refuses to make a snap' diagnosis and who collects and interprets wisely all of the pertinent facts from the history physical examination and laboratory tests will in many instances arrive at a satisfactory understanding of the problem (Barr)

Any physician who is acquainted with the classical complaints and is accustomed to examining patient s backs and testing reflexes and sensations in the lower extremities can diagnose a ruptured disk with a high degree of accuracy (Noyes and Hunter)

Not all disk prolapses produce symptoms of sciatica, nor are all sciatic troubles due to disk protrusions One must keep an open mind in spite of the presence of seemingly positive evidence and by the same token in spite of the absence of accepted prerequisite evidence One should ' never make a major diagnostic or therapeutic decision on the findings of one examination or on the basis of any isolated or specific observation ' Often

* A quick unexpected blow on a buttock causes pain in the back then in a buttock

If rest in bed relieves the pain it speaks for a disk lesion. If tolserol given intravenously, relieves the pain, it speaks for a disk lesion.

If the following therapeutic measures relieve the pain it speaks for a diagnosis of a disk lesion:

Rest in bed, fetal posture rigidity of mattress Tolserol I-V.

If a disk patient stays in bed long enough he will get relief. This is not true in a cord tumor patient (Ray).

Progressive pain is more characteristic of tumor. When pain is so severe that the patient cannot be kept in bed the lesion is more likely to be a spinal cord tumor. *Corollary* — The person with a disk derangement wants to stay in bed and will usually show improvement therefrom.

FAVORITE DIAGNOSTIC TESTS OF VARIOUS AUTHORITIES "PET DIAGNOSTICATORS AND PROGNOSTICATORS"

Each authority on the subject of disks, has his "pet" signs and symptoms upon which he makes a diagnosis and recommends treatment. From his own experience every surgeon arrives at the stage where he has his "pet" diagnostic indicators. This is derived from his repeated audition of histories, his many physical examinations and special tests and careful studies of *x*-rays. From these elements he coordinates and integrates his own and the experience of others with his observations and the results of conservative and operative treatment. These may serve *him well* but may *mislead others*. I have termed them indicators.

One expert considers the Lasegue test the most valuable.

Others believe that the straight leg raising test is more valuable than all other clinical or radiological signs combined not only in the diagnosis but also in estimating the prognosis following surgery.

Another writer attaches undue importance to the Achilles reflex.

Pennybacker considers the Naffziger test plus pain on lumbar pressure (while the patient lies prone) to be a valuable diagnostic aid.

SCREENING OF DISK CASES FROM THE FIELD

The Disk Divide.—In the general run of patients whose *presenting* symptom was backache, I have found the following schematic formula very helpful in differentiating a case of protruded disk from other disorders.

LOCALIZATION AIDS

The syndrome of sciatica due to a prolapsed intervertebral disk consists of symptoms and signs resulting from irritation of a single nerve root. The muscles supplied by the root are tender painful and weak while pain radiates along the dermatome and frequently paresthesia, numbness, sensory loss and interference with the reflex arc are present.

The diagnosis of a ruptured disk at the 4th or 5th lumbar interspaces can be made with reasonable assurance. Since it has been demonstrated by Love and Spurling that over 96 per cent of all lumbar vertebral disks are at the 4th and 5th lumbar spaces and since the unilateral approach is

It would be ideal if every person with a resistant backache and sciatica could be examined by (1) An orthopedic surgeon, (2) a neurologist and (3) a neurosurgeon In addition some should be examined by a gynecologist or a urologist

The diagnosis is made on the basis of low lumbar backache plus pain down one or both legs The pain is intensified by coughing or sneezing The snuff test is helpful in cases where a disk lesion is suspected It also helps in localizing the point of origin of the back pain Faradic stimulation of hyperalgesic nerves may be of diagnostic help

Inspection includes observations under the following situations

While history is being taken	While sitting
While patient is disrobing	While kneeling
While he is standing	While lying prone
While walking	While lying supine

The profession must not permit the diagnosis of a disk syndrome to become a "dumping ground" for inadequate knowledge interest observation and study A diagnostic suspicion may be based entirely upon the negative evidence that there is no other reasonable explanation for the signs, symptoms and physical findings in a particular case One may find nothing but the isolated symptom of radiating pain and a positive Lasegue s sign in one lower extremity, on which to base a diagnosis

Distribution of pain and numbness, muscle weakness reflex changes sensory alterations and the level of local tenderness in the back, are of diagnostic value

One must never lose sight of (1) The diagnostic significance of a *sneeze* or a cough that aggravates backache and sciatica

(2) The diagnostic significance of *limp*

(3) The diagnostic significance of *stubbing toes*, getting up a curb, indicating weakness of extensor muscles of a foot or big toes

1 *Therapeutic Differential Diagnostic Test*

Traction vs Fetal Posture If	The Probability is
If the fetal posture gives relief	One *is* confronted by a space occupying lesion
If straight leg traction or pelvic traction give much relief	One *is not* confronted by a space occupying lesion

The therapeutic test of {
rest
posture
immobilization
physical-therapy
nucleotherapy-direct injection

Radiating pain and the Lasegue sign may lessen or disappear after resting in bed

Therapeutic Test —If the fetal posture relieves the symptoms the diagnosis is more likely to be a disk If straight leg or pelvic traction relieves the symptoms, the diagnosis is less likely to be a disk

or Ely-Nachlas test I have used it routinely for forty years in every "back examination," as a test for psoas muscle irritation, especially as an indicator of a tuberculous abscess

In cases of a herniated fourth lumbar disk there is a reduced or absent ankle jerk If the first sacral nerve root is involved, the pain will radiate into the midbuttock and the posterior aspect of the thigh and calf Neurologic findings may be indistinguishable in disk protrusions above and below the fifth lumbar vertebra

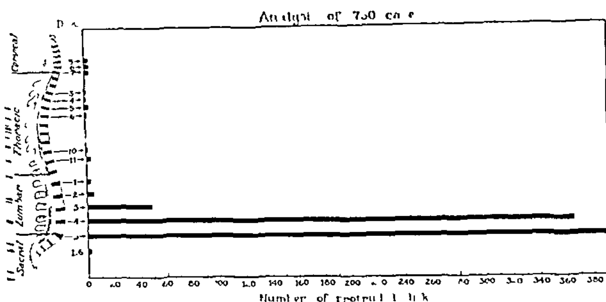


Fig 356 —Frequency of protrusion of different intervertebral disks into the spinal canal On the left a median section of the normal spinal column and on the right the interspaces and the numbers of protruded intervertebral disks which occurred in those inter paces L6 refers to the number of protruded intervertebral disks which were found in those cases in which there were 6 lumbar vertebrae (Note Although these figures were compiled in 1943 they were still accurate up to 1952) (Love and Walsh courtesy of Surg Gynec & Obst)

In summarizing the diagnostic signs and symptoms of intervertebral disk lesions Spurling and Grantham tabulate the localizing data as follows

A *Third lumbar interspace,*
1 Disability of the lower part of the back, with local tenderness to deep pressure over the third lumbar spine or lamina and reduction of lumbar lordosis
2 Positive Lasègue test
3 Positive Naffziger test, a positive jugular compression test producing paresthesias in the 4th and 5th lumbar dermatomes
4 Reduction or absence of the knee jerk ankle jerk unchanged
5 Hyperesthesia and paresthesia in the 4th and 5th lumbar dermatomes

B *Fourth lumbar interspace*
1 Disability of the lower part of the back with stiffness of the lumbar portion of the spine and localized tenderness to pressure over the 4th spinous process or lamina with reduction of lumbar lordosis
2 Positive Lasègue test
3 Positive Naffziger test with paresthesias involving the 5th lumbar the 1st sacral and perhaps the 2d sacral dermatomes
4 Ankle and knee jerks uninvolved
5 Hyperesthesia and paresthesia in the 5th lumbar and first sacral dermatomes

adequate to find the lesion whether it involves the 4th or the 5th disk, it is only necessary to make the diagnosis of a lumbar vertebral disk in order to disclose its approximate location and remove it

Compression of a sacral root is indicated by Pain limited to a specific distribution, sensory disturbances, muscle power changes, reflex changes

In cases of protrusion of a disk at the 3d lumbar level, the pain will be localized to the front of the thigh Burns and Young found that protrusions of the disks below L 3 or L 2 produce signs of irritation of the femoral nerve and not of the sciatic The back signs are similar except that the radiating pain tends to be at a higher level They found that the "femoral stretch sign" replaces the Lasègue test as a diagnostic aid, in these cases

O Connell found that the stretch test produces tension in or on a nerve by hyperextension of the hip and increases the pain, if either the second or third lumbar disk is protruding The femoral stretch sign is the old Ely

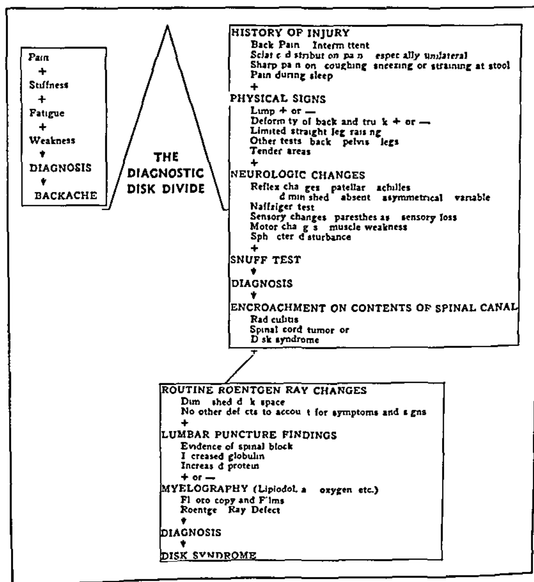


FIG 355 —The diagnostic disk divide

Terminology.—Designation of location or identification of interspaces and disks. Various writers use different terms to express the location of the lesion. Some use the following:

1. "Between 4th and 5th Lumbar Vertebræ"
2. "L4/5 disk"
3. "Below L4" (This is my preference)

Localization of the lesion can be usually approximated, at times estimated or aided, and occasionally determined by:

1. Symptoms
2. Signs
3. Physical tests
4. Percussion
5. Neurological tests
6. Radiation
7. Dermatome determination
8. Electrical stimulation

It is always relative (it is never absolute).

Schlesinger and Stinchfield offer the following useful "generalities" in the examination of suspected "disk" cases:

1. Pain and sensory changes along the outer aspect of the dorsum of the foot, suggest involvement of the first sacral root (L5 to S1 interspace).
2. Pain and sensory changes in the great toe, suggest implication of L5 root (L4 to L5 interspace).
3. Radiation of pain across the mid-line of the anterior thigh toward the adductor aspect, is indicative of root involvement above L4 interspace and deserves myelographic confirmation.
4. Focal motor weakness is not of localizing value in lumbosacral root compression because of the characteristic multiple innervation of the muscles of the lower extremities. Sensory changes are much more specific. This is exactly the opposite of the situation in the cervical region.
5. Depression of the Achilles reflex is compatible with either an L4 to L5 or L5 to S1 lesion; depression of the knee jerk is suggestive of the higher level.
6. The posterior tibial reflex (when present bilaterally) absolves compression of the L5 root at L4 to L5 interspace. Conversely, its absence unilaterally, specifically indicts L5 root at L4 to L5.
7. Difficulty in regaining the erect posture from a flexed position is common in L4 to L5 lesions.
8. Pain on the side opposite an obvious lesion, while usually due to traction on the contralateral root by a large lesion, may be due to a lesion at another level and deserves myelographic confirmation.

In making a differential diagnosis, one must review the cardinal signs and symptoms of every lesion that is known to produce similar trouble. One must consider the diagnostic features of each. One must visualize the x-ray findings of each. Special studies, special tests and myelography are necessary in some cases.

SPECIFIC AIDS IN DIFFERENTIATING DISK DISORDERS FROM TUMORS

Intermittency of Symptoms.—A person with a spinal cord tumor does not give a history of the intermittency of his symptoms. In disk disorders

C *Fifth lumbar interspace*
1 Disability of the lower part of the back with absence of lumbar lordosis and localized tenderness to pressure over the 5th lumbar vertebra
2 Positive Lasègue test
3 Positive Naffziger test, producing paresthesias radiating into the 1st and 2d sacral dermatomes
4 Diminution or absence of ankle jerk
5 Hyperesthesia or paresthesia involving the 1st and 2d sacral dermatomes

The fifth lumbar nerve is usually affected at the level of the fourth disk and the first sacral nerve at a point opposite the lumbosacral disk Keegan finds that the nerve root most commonly compressed by a herniated intervertebral disk is the first sacral Recognition of the syndrome of lesions of the first sacral nerve root with its characteristic dermatome hypalgesia and loss of the ankle jerk eliminates extraspinal lumbar pathology as a possible cause, as this nerve root is entirely intraspinal until it makes its exit through the first sacral foramen

Neurological signs are not always accurate in localization, particularly in lesions involving the lower two disks O Connell s tables indicate that they can at most, suggest a probability He has presented an original explanation for this in what he calls occult sacralization Here the lowest free vertebra is on a higher level than usual and the upper component of the sciatic nerve comes out below instead of above it

Dandy's Localization Test —Dandy considered the test of local spinal hypermobility to be reliable in localizing a disk lesion in 85 per cent of cases He emphasized the free play at the level of the aggravation of pain by coughing and sneezing

Burns and Young find that while it is possible to localize the lesion to the spaces below L4 or L5, it is impossible to differentiate, clinically, except in the presence of a well marked scoliosis Sciatic scoliosis is usually due to a disk lesion below the 4th lumbar vertebra

A disk lesion below L5 usually causes a slight side body *tilt* or *list* on forward bending to avoid nerve pressure If the protruded disk is central or in the axilla of the root, the tilt will be homolateral (The "axilla' is formed by the root and the spinal cord) If the protrusion is *lateral* to the nerve root the tilt will be heterolateral

Disk lesions may be encountered at the 2d and 3d lumbar interspaces but the symptoms are sufficiently different (usually pain in the front of the leg or diminution of the patellar reflex) to suspect a lesion at a higher level than the usual one

With the characteristic pain in the lower lumbar region and down the hip and back of one or both legs, the affected disk is therefore nearly always at the 4th or 5th lumbar and it has been necessary to explore only one or both of these disks Frequently there is a clue, such as a reduced or absent Achilles reflex, which points to the 5th although it may also occur when a lesion is at the 4th interspace

Identification of a Specific Nerve Root in Relation to a Lesion of a Specific Intervertebral Disk —When a surgeon has concluded that a patient has a disk lesion he is confronted with two problems (1) Identification of the nerve that is in trouble (2) Localization of the point of impingement

CHAPTER 55

LOCALIZATION OF THE LESION

The Significance of Certain Tests.—I have cross-catalogued the factors in the problem of localization. For example: *A* If the 4th nerve is involved, there are specific indicators. *B* If the Achilles reflex is out, a specific nerve area is involved.

A reduced or absent ankle jerk indicates an involvement of L5 to S1. It is not pathognomonic in itself.

A large disk can be present with a normal ankle jerk. One is much more likely to find an absent ankle jerk in L5 to S1 lesions than in L4 to L5 lesions.

The Significance of Big Toe Tests.—Inability to dorsiflex the big toe against resistance means loss of power of the anterior tibial muscles that are supplied by the common peroneal nerve which arises in L4 to L5 and S1 to S2.

Inability to dorsiflex the foot against gravity or resistance has a certain implication.

Inability to use the tibial muscles normally indicates tibial nerve involvement, *i.e.*, L4 to L5, S1 to S2 to S3.

Inability to use the peroneal muscles normally indicates involvement of the superficial peroneal which arises at L4, L5, S1.

Inability to use the gastrocnemius muscle normally means involvement of the tibial nerve which arises at S1, S2.

Since the herniated nuclei pulposi compress the spinal nerves near their only exits from the spinal canal, the radicular neurologic findings localize the lesion.

Keegan suggests that it would be simpler and more accurate to identify the vertebra by means of a total numerical series, with the corresponding disk and nerve root immediately below. He advises the use of light pin prick or scratch by the free hand, beginning in the leg or foot where the dermatome areas of hypalgesia are most easily demonstrated. The pin is passed from the slightly reduced zone to the normal sharper zone, and the patient reports when the pain definitely becomes sharper. The line of transition is drawn with surprising constancy by the patient's signal, and follows the same pattern in different individuals.

Sciatic Scoliosis.—Scoliosis may be Ipsilateral, Homolateral or Heterolateral. The significance of voluntary and involuntary splinting of the paravertebral muscles should be recognized.

In cases of curvature of the back one should determine: Can it be corrected by the patient? Can it be reversed by the patient? *i. e.*, are you dealing with an *alternating scoliosis?* A contralateral Lasègue test is a sign of a radicular syndrome.

Interpretation and Evaluation.—Evidence may be compatible, incompatible, indicative, decisive, or indecisive. The evidence may be *pre-*

the course is usually intermittent or episodic In spinal cord tumors the signs and symptoms usually become progressively worse

Relation to bed rest A person with a disk lesion wants to stay in bed A person with a spinal cord tumor wants to get out of bed

A *large disk* acts like a *tumor*

A *small tumor* acts like a *disk*

Multiple disks act more like tumors

Spinal tumors usually will give some sensory or motor disturbances early in the disorder

The results as confirmed at operation are sufficiently accurate to compare favorably with more complicated technics.

Using this method, referred pain is considered of no localizing value unless it is felt below the knee. When pain is felt below the knee the areas corresponding to the various roots are indicated in the table below.

Using this simple chart, it is not difficult to relate referred pain below the knee to one of the three broad areas described. This indicates the root involved and localizes the site of the disk lesion with considerable accuracy. Common sites for such painful patches of skin are the antero-lateral aspect of the ankle when the fifth lumbar root is involved and the posterior aspect of the heel when the first sacral root is irritated.

Type and Intensity of Pain.—Pain referred to the legs may be of two types. 'Deep' referred pain is of a dull, aching character and is poorly localized by the patient. Superficial pain is sharp, well localized and appears to originate in the skin and subcutaneous tissues.

sumptive or positive The evidence may be at hand and its interpretation and significance may be difficult and indecisive

Armstrong designed a fairly simple scheme to correlate the level of the disk lesion and the site of referred pain He described it as follows

From the segmental point of view the L5 to S1 disk and the mesodermal elements in the legs supplied by the first sacral nerve roots are of the same embryonic level, and the same is true of the L4 to L5 disk and the structures supplied by the fifth lumbar root

"Deep" or sclerotogenous pain originating from these disks would, if referred to the legs, be felt mainly in the muscle groups supplied by the corresponding roots

Root	*Site of Pain*	*Myotomal and Dermatomal Levels*
4th Lumbar (L3 L4 disk)	Anterior or antero-medial aspect of leg below the knee	*Dermatome* Skin of the antero medial aspect of leg below knee (probably variable) *Myotome* Anterior tibial muscles (fourth and fifth lumbar roots)
5th Lumbar (L4 L5 disk)	Antero lateral aspect of leg below the knee Dorsum of foot	*Dermatome* Antero-lateral aspect of leg below knee and dorsum of foot *Myotome* Anterior tibial (fourth and fifth lumbar roots) and peroneal (fifth and first sacral roots) muscles
1st Sacral (L5 S1 disk)	Posterior aspect of leg below knee Sole of foot	*Dermatome* Posterior aspect of calf and sole of foot *Myotome* Muscles of calf (first and second sacral roots)

Armstrong Lumbar Disk Lesions (courtesy of Williams & Wilkins Co)

Referred pain due to root irritation is felt in the dermatome supplied by the root involved The first sacral roots are in close relationship with the L5 to S1 disk the fifth lumbar roots with the L4 to L5 disk, the fourth lumbar roots with the L3 to L4 disk the third lumbar roots with the L2 to L3 disk and the second lumbar roots with the L1 to L2 disk

When a lesion of the L5 to S1 disk produces pain referred to the legs this pain may be felt either in the myotome supplied by the first sacral root if it is "deep" pain or in the dermatome supplied by the first sacral root if it is associated with root irritation In a similar way the L4 to L5 disk is related to the fifth lumbar root and the upper lumbar disks with corresponding roots

From a practical point of view Armstrong finds it is not necessary to differentiate between these two types of referred pain although it is often possible to do so It is sufficient to decide if the referred pain is of monoradicular distribution and then to determine with which root, and therefore with which disk, it is associated The method of localization is simple

to be pathognomonic for herniated intervertebral disks, was present in 60 per cent of Love's cases of herniated disks and in 23 per cent of intraspinal tumors

Raney finds that when space-occupying lesions in or about the spinal canal enlarge sufficiently, they involve one or more spinal roots If such lesions, *e g*, neoplasms posterior herniations of the nucleus pulposus, etc, involve a spinal root, the earliest symptom is an irritative one, pain On the other hand, if these lesions have their origin within or adjacent to the spinal cord they may give signs of involvement of the spinal pathways, in which case pain may not be the initial symptom However, pain usually appears long before subarachnoid block and serious spinal cord changes occur

A tumor of the spinal cord	Vascular lesions—thrombophlebitis
A tumor of the cauda equina	Tuberculous spondylitis
A tumor of a spinal nerve	Osteoarthritis
A benign or malignant tumor of a vertebra	Rheumatoid spondylitis
Spondylolisthesis	Epidural abscess
Sacralized transverse process	Osteoporosis
Certain neurological lesions	Fibrositis
A vertebral injury—Fracture—Body—Process	Lumbago
A destructive lesion of the spine	Paget's disease
Infectious spondylitis	Hemangioma
Sacroiliac lesions	Myofascial strains
Hypertrophy of ligamentum flavum	Ligamentous strains
Hip disease	Sacroiliac strains
	Lumbosacral strains
	Postural strains

Keegan finds that nerve root compression by tumors of the vertebra or tumors within the spinal canal is a common cause of confusing abdominal pain The clue to the correct diagnosis is the radiating band like character of the pain extending obliquely around from a tender place in the spine In addition there is likely to be some reduction of sensation or hypalgesia in the distribution of the compressed nerve root best demonstrated by very light pin scratch, scratching outward from the segmental pain zone If the tumor within the spinal canal is large enough to compress the spinal cord, there will be some sensory and motor loss in the lower extremities or bladder In such cases one may demonstrate the upper limit of this sensory loss by extending the pin scratch upward from the extremities over the abdomen when the patient will report that the pin seemingly becomes sharper at a definite oblique segmental line where normal sensation begins One of the most valuable signs is that the pain and hypesthesia in front are at a lower level than the vertebrae involved

The most important differentiation is between an intraspinal neoplasm and a protruded disk Neoplasms cause bilateral symptoms and signs impaired sphincter control, a block of the spinal canal, and more than one hundred milligrams of protein in the spinal fluid When a protruded disk is large it may act like a tumor, and when the tumor is small it may be

CHAPTER 56

DIFFERENTIAL DIAGNOSIS

The differential diagnosis includes its determination from other lesions, from each other and from multiple lesions The differential diagnosis may be divided into those conditions of low-back pain which are accompanied by sciatica and those which are not There are many lesions that can give symptoms similar to those of a protruded disk The differential diagnosis includes

- Tumors of Nerves or Bones
- Mechanical Lesions such as Spondylolisthesis
- Arthritis and Related Diseases
- Fibrositis
- Infectious Diseases—Tuberculosis, Syphilis Brucellosis and others
- Diseases of Central and Peripheral Nervous System—Neuritis, Herpes Zoster
- Nutritional Disturbances
- Degenerative Lesion—Charcot Lesion
- Postural Disorders
- Tight Ilio-tibial Band
- Bursitis—Gluteal

I disagree with those who believe that the differential diagnosis of disk disorders depends on the *x*-ray I believe it depends on the neurological examination I also disagree with the thought that the *x* ray is an important indicator of appropriate treatment The patient s history and the physical examination determine the course of treatment

Always get the opinion of a neurologist but never be as pessimistic as he is Always get the opinion of a neurosurgeon, but never be as optimistic as he is

There are many lesions of the spine and many outside the spine itself which may produce pain in the back Some of the most important conditions which have clinical features simulating those of a protruded lumbar disk are listed on opposite page

Young emphasizes the fact that the lesion responsible for the low-back pain and pain in the leg is not always situated in the spinal column or spinal canal One must be prepared to look elsewhere Young reported several cases in which the symptoms closely simulated those caused by protrusion of an intervertebral disk These cases included an osteoid osteoma of the femur a glomus tumor of the leg a twisted ovarian cyst multiple myeloma of the spinal column, eosinophilic granuloma of the pelvis chondromyxo sarcoma of the femur, and tuberculous arthritis of the sacroiliac joint

One must be on constant guard to recognize tumors affecting the spinal cord that masquerade with the identical symptoms of protrusion of an intervertebral disk Loss of the Achilles tendon reflex considered by some

RAY DIVIDES THE LESIONS TO BE CONSIDERED AS FOLLOWS*

A Intradural tumors of the conus medullaris or cauda equina
B Radiculitis
  Idiopathic
  Herpes zoster
  Localized leptomeningitis
C Intraspinal extradural tumors
D Extraspinal nerve lesions
  Lumbosacral plexus pressure or invasion by pelvic neoplasm
  Lumbosacral plexus pressure during pregnancy and labor
  Neurofibroma of sciatic nerve
  Tumors compressing the sciatic nerve

TABLE 6 —RAY'S LIST OF SIGNS AND SYMPTOMS OF LESIONS SIMULATING DISK PROTRUSION*

Comparison of Symptoms in Protrusion of Lower Lumbar Disk and Intraspinal Lumbar Tumor

	Disk	*Tumor*
Influence of injury	Common	Occasional
Recurrent attacks	Common	Occasional
Backache	Usual	Occasional
Limited back movement	Usual	Rare
Deviation of spine	Common	Rare
Painful extremity		
Laterality	Usually unilateral	Usually bilateral
Degree	Rarely severe	Often severe
Increase on straining	Usual	Less common
Effect of rest	Improves	Gets worse
Position of comfort	Lying	Standing
Paresthesias and numbness	Unilateral leg foot and specific toes	Often bilateral and includes saddle
Motor loss	Occasional acute foot drop	Gradual weakness in extremities
Painful limp	Usual	Rare
Sphincter loss	Rare	Common

* Am Acad Orth Surg Instructional Courses 1953

TABLE 7 —RAY'S COMPARISON OF PHYSICAL AND LABORATORY FINDINGS IN PROTRUSION OF LUMBAR DISK AND INTRASPINAL LUMBAR TUMOR*

	Disk	*Tumor*
Gait	Painful unilateral limp	Normal to marked weakness usually without pain
Posture	Scoliosis Flattening	Usually normal
Back bending	Limited	Often normal
Spasm and tenderness of lumbar muscles	Common	Uncommon
Muscle weakness in extremities	Unilateral common	May be bilateral Fibrillations common
Sensory changes	Typical pattern	Atypical pattern Common saddle loss
Lasegue's sign	Usually positive	Not common or of less degree
Spinal fluid protein	Commonly normal Rarely > 100 mg	Rarely normal Commonly > 100 mg
X ray spine	Rarely helpful	Occasionally helpful
Spinography	Often unreliable	Rarely unreliable

* Am Acad Orth Surg Instructional Courses 1953

indistinguishable in its clinical manifestations from a protruded disk. The symptoms of a protruded disk may have a relatively insidious onset while those of an intradural tumor may have a relatively acute onset and it may be associated with physical strain.

COMPARATIVE SYMPTOMS IN 285 CASES[1] OF PROTRUDED INTERVERTEBRAL DISK AND 154 CASES OF INTRASPINAL TUMOR FOR DIFFERENTIAL DIAGNOSIS
(Craig and Walsh[2])

Symptoms	*Protruded Intervertebral Disk* *Per cent*	*Intraspinal Tumor* *Per cent*
Unilateral sciatic pain	75	38
Bilateral sciatic pain	15	23
Low back pain	95	42
Nocturnal pain	21	47
Sphincteric incontinence	5	33
Lasègue's sign present	81	14
Achilles reflex diminished or absent	60	23
Hamstring reflexes diminished or absent	18	27
Muscle paresis	22	42
Muscle atrophy	2	25
Sensory loss	22	64
	Disk	*Tumor*
Laterality of symptoms	Unilateral	Bilateral
Impaired sphincter control	—	+
Block with more than 100 mgm. protein	—	+
Onset	Insidious	Acute
Remissions	Common	Not Common
Therapeutic Test	Bed rest helpful	Bed rest not helpful

[1] These 285 cases represent those in which sensory changes were present. They are part of the complete series of 500 cases of single and multiple protrusions of the intervertebral disk in the lumbar region.
[2] J. Bone and Joint Surg., April 1941.

Bosworth approaches the problem from a different angle. He lists conditions which can simulate posterior herniation of the nucleus pulposus of the intervertebral disk as follows:

TABLE 5

TUMOR	Intradural*
	Extradural
SPINAL	Tuberculosis*
	Carcinoma*
	Facet fracture*
	Spondylolisthesis
	Osteoarthritis
	Spondylitis
	Ligament tear
HIP	Malum coxæ senilis
SACROILIAC	Tuberculosis
FEMORAL	Osteoid osteoma*
NEUROGENIC	Herpes zoster
	Degenerations
	Hemiplegia
	Sciatic trauma
MUSCLE	Avulsion
BURSAL	Trochanteric, etc.*
VASCULAR	Phlebothrombosis
ABDOMINAL	Lymphosarcoma
PELVIC	Prostate
	Rectum
	Uterus—adnexæ

* Items marked are the most important.

Ray Divides the Lesions to be Considered as Follows

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VASCULAR	Phlebothrombosis
ABDOMINAL	Lymphosarcoma
PELVIC	Prostate
	Rectum
	Uterus—adnexæ

* Items marked are the most important.

Source of Error.—Most errors in diagnosis are due to gross neglect in obtaining a complete history, in making a careful examination and in having adequate diagnostic roentgenograms. A routine examination requires adequate exposure of the affected area. Errors in the interpretation of roentgenograms may be due to many sources, chief of which are variations in posture and technic. Negative roentgenograms may be very misleading.

Confusing data { 1. Bilateral Signs and Symptoms
2. Loss of Sphincter Control

There may be many symptoms and signs, the most confusing of which are bilateral ones and impairment of sphincter control. The protruded disk is not always where the *x*-ray reveals a narrowed interspace.

The probability in error is that the diagnostician has suspected the lesion to be at a lower level than it is. Correct ' the estimation of localization to a higher level until the situation is proven otherwise. The passage of time will diminish the possibility of error in diagnosis.

Armstrong feels that most serious errors of diagnosis concerning patients complaining of symptoms in the low back and in the legs are due to failure to recognize a spinal tumor in its early stages. He finds that intraspinal tumors are responsible for the symptoms in 5 per cent of all patients who require laminectomy for associated symptoms in the low back and in the legs.

In any case of unexplained, intractable, root pain and in almost every case in which protruded intervertebral disk is suspected, Love advises a diagnostic lumbar puncture and a determination of the protein content of the cerebrospinal fluid. A value for spinal fluid protein of more than 100 mg. per 100 cc. usually means a neoplasm rather than a protruded intervertebral disk.

Love discussed a series of confusing cases which included 26 cases of spinal cord tumors which could not be differentiated clinically pre-operatively from disk lesions. Eight per cent of his tumor cases masqueraded as disks. If spinal fluid protein is 100 mgm. it is against the diagnosis of a disk lesion.

In an analysis of the records of 26 cases of tumor of the spinal canal in which symptoms of root pain suggested irritation or compression of the spinal cord or nerve roots by a protruded intervertebral disk, Love found that diagnostic spinal puncture, with or without visualization of the spinal canal, was essential to diagnosis and to localization of the intraspinal lesion.

In a series of 15 cases of tumor of the spinal canal it was found that in 8 the symptoms were misleading in that they suggested protruded intervertebral disk. Also during the period when these 15 patients came to operation, 100 other patients were subjected to operation for protruded intervertebral disks.

There are five reasons why Camp advises intraspinal investigations on all patients suspected of having a protruded lumbar disk.

1. Tumors of the spinal cord in, and cephalad to, the lumbar region may simulate the signs and symptoms of a protruded intervertebral disk.

Steindler differentiates *true reflex sciatic pain* from *organic radiating or referred pain*. The more one analyzes the early case histories of proved herniated disks, the more difficult it seems to be to distinguish the early low-back and irritative nerve root symptoms from many other conditions, and the suspicion is growing that most of these low-back syndromes are related to disk pathology, and not to the many other conditions previously postulated. Reflex pain cannot be used to explain sensory, reflex, or motor loss in an extremity. There must be some organic pathology in the nerve or nerve root.

On the basis of 800 cases, Pennybacker stressed the importance of differentation from cases of neoplasm which were often misleading in their symptoms, but in which the neurological signs were usually progressive. Occasionally, radiographs would show scalloping of the vertebral bodies or increased width between the pedicles, lumbar puncture usually revealed an increased protein content of the cerebrospinal fluid, and as a rule myelography established the diagnosis.

Intraspinal tumors are more difficult to diagnose early than vertebral tumors causing nerve root pain, for there is no *x*-ray evidence until late when the spinal cord and lower extremities obviously are involved. It is a common observation that a number of these slowly developing cases have had some abdominal operation performed before clear neurologic symptoms develop. More careful check of the band-like radiating character of the pain from the spine and sensory testing by light pin scratch for faint segmental sensory reduction or hypalgesia should give the clue to the correct diagnosis. A high percentage of the tumors which develop within the spinal canal are benign and completely removable, as the small olive-sized neurofibroma and meningioma. Incomplete removal of other less benign, extramedullary intraspinal tumors gives immediate relief of cord compression and prompt recovery of lower extremity and bladder paralysis lasting a variable time depending on the degree of malignancy of the tumor and the response to radiation therapy.

Keegan finds that tumors of the vertebræ compressing nerve roots may be metastatic from breast or prostate, the former being more common in the thoracic spine where the nerve roots supply the abdominal wall. It is a common mistake when searching for the cause of such nerve root pain located in the abdomen to take *x*-rays of everything there, and miss by only a few vertebræ the evident bone destructive lesion at the mid thoracic level. It is well to remember that the level of the umbilicus is supplied by the tenth thoracic nerve and that this nerve root ascends two or three vertebræ higher in the spinal canal before it emerges from the spinal cord. Thus a nerve root pain syndrome at the level of the umbilicus requires an *x*-ray centering on the seventh thoracic vertebra for demonstration of causative bone pathology. The breast, prostate and abdominal organs should be carefully examined for primary carcinoma.

Neurosis.—Occasionally it may be difficult to differentiate between hysteria and a disk syndrome. The signs and symptoms of a neurosis are usually out of all proportion to the responses to the special tests and the roentgen ray findings.

Trauma of relatively slight degree was the etiological factor in the majority of Brown's patients. Pathological changes in the involved ligaments were demonstrated microscopically.

After their exit from the dura, the nerve roots lie in the very narrow space between the ligamentum flavum and the intervertebral disk.

Compression of spinal nerve roots by the enlarged ligament produces symptoms and signs. The clinical syndrome is difficult to differentiate from lumbosacral or sacro-iliac disorders.

Hypertrophy of the Ligamentum Flavum as a Cause of Low-back Pain. — Enlargement of the ligamentum flavum producing compression of nerve roots is a cause of low-back pain with sciatic radiation. Elsberg in 1913 described a typical case of compression of a spinal nerve root following

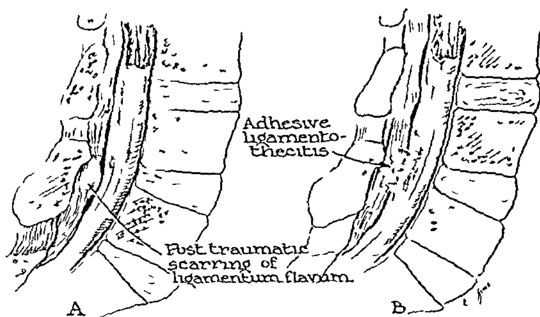


Fig. 367.—Adhesive ligamento-thecoitis. Injury to the ligamentum flavum results in scar tissue which becomes adherent to the adjacent dura. Symptoms are due to direct pressure plus traction on the thecal sheath.

trauma. An enlargement of the ligamentum flavum was found at operation and complete relief of symptoms followed its removal. In 1916, the same author reported 2 more cases of enlarged ligamentum flavum. In 1931, Towne and Reichert reported 2 cases without antecedent trauma.

Anatomical study of the ligamentum flavum shows that even a moderate enlargement may cause compression of spinal nerve roots. The intervertebral disk lies directly below each ligament and the very narrow space between them serves as a passage for the nerve root after it emerges from the dural canal. An increase in the size of the ligament, a posterior protrusion of the disk, or a combination of the two, may compress the nerve root.

At times they may undergo hyperplastic change and encroach on the spinal canal, thereby compressing the spinal cord. This hyperplasia presumably is possible at any level. Spurling, Mayfield and Rogers reported 7 cases where the involvement was limited to the ligaments connecting the

2 Protrusion of the third, second, or first lumbar intervertebral disk may produce signs and symptoms commonly seen in protrusions occurring at lower intervertebral levels

3 Multiple protrusions occur in about 18 per cent of all cases of protrusion of an intervertebral disk, and since they may involve contiguous or scattered intervertebral spaces, contrast myelography is the only practical method by which they may be accurately localized prior to operation

4 In rare instances a protruded lumbar intervertebral disk and a tumor *of the spinal cord may coexist, giving rise, usually, only to the typical signs* and symptoms of protruded disk

5 When contrast myelography is employed, the lesion is accurately localized in a high percentage of cases, thus the necessity of entering normal interspaces is obviated

There is increasing evidence of the incidence of bilateral herniated disks There is increasing evidence of the incidence of multiple disk lesions synchronously or concurrently

Concomitant cervical and lumbar disk lesions are encountered occasionally A person may have a lumbar and a cervical disk syndrome at the same time or he may have them concurrently in either sequence

Combinations of Lesions Involving a Disk Syndrome

1 Arthritis superimposed on a disk syndrome
2 A disk syndrome superimposed on arthritis
3 Multiple disk lesions
4 Disk lesions in the cervical and lumbar regions
5 Congenital anomalies
6 Mechanical derangements
7 Infection Osteomyelitis-brucellosis
8 Post-traumatic (post-operative arachnoid cysts)

These combinations are important practically and medico-legally Nothing makes a 'doctor s face as red ' as to have some lesion discovered by another doctor, especially if it is aired for the first time, in court

LIGAMENTUM FLAVUM

The ligamenta flava are composed normally of yellow elastic tissue and connect the laminae of contiguous vertebrae They blend with the interspinous ligament and enter into the formation of the capsules of the joints between the articular facets their lateral edge forms the posterior margin of the intervertebral foramina

Brown describes these ligaments as arising from the dorsal and upper margins of each lamina passing upward beneath the lamina immediately above, and entering the neural canal They fuse in the mid line and their lateral expansions *extend well down toward the anterolateral* aspects of the neural canal, forming the posterior margins of the intervertebral foramina The ligaments lie in close association with the articular facets in the neural canal, and to some degree, from a capsular covering for the vertebral articulations

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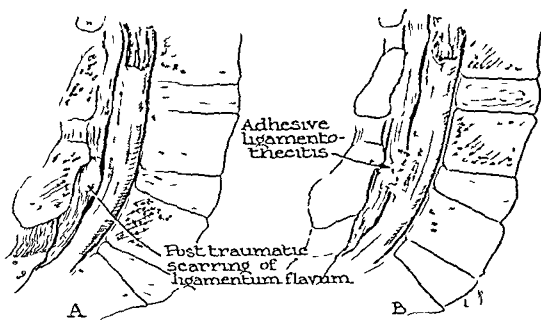


Fig. 357. – Adhesive ligamento-thecitis. Injury to the ligamentum flavum results in scar tissue which becomes adherent to the adjacent dura. Symptoms are due to direct pressure plus traction on the thecal sheath.

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At times they may undergo hyperplastic change and encroach on the spinal canal thereby compressing the spinal cord. This hyperplasia presumably is possible at any level. Spurling, Mayfield and Rogers reported 7 cases where the involvement was limited to the ligaments connecting the

4th and 5th lumbar vertebrae In 6 of the 7 cases the lamina of the 4th lumbar vertebra was likewise found to be greatly increased in thickness

Dockerty and Love suggest the term "thickening with fibrosis" Objectively, the most common findings in Brown's patients were some degree of scoliosis with a list to the unaffected side, a general restriction of movements of the back, and limitation of straight-leg raising on the involved side Local tenderness over the lumbar spine was present, but was seldom severe

Treatment consists of a wide lateral removal of the enlarged ligament in order to free the nerve root from compression

Seven patients with enlargement of the ligamentum flavum were operated on by Love over a period of seven months Operative removal of the enlarged ligament produced prompt relief of pain with gradual improvement in the impaired motor and sensory functions

I have found at operation in several cases, fusion or agglutination of the ligamentum flavum and the dura, which I call ligamento-thecosis or adhesive ligamento-thecitis

Hypertrophy of the ligamentum flavum, which was described in several early articles as a cause of nerve root compression by foramen narrowing, is now questioned It is theoretically possible that prolonged insult to this interlaminar and interarticular ligament following a back injury, whether the disk is ruptured or not, may conceivably result in thickening sufficient to encroach upon the intervertebral foramen These structures were extensively explored by Cloward in performing his disk operation Examination in over 450 patients who underwent disk operations has failed to convince him that hypertrophy of the ligamentum flavum as a definite pathologic entity, does exist

CHAPTER 57

PROGNOSIS

The prognosis in disk lesions depends to a degree on the first doctor who sees the patient, the diagnosis he makes and what he does about it.

The fundamental principle upon which good results are obtained is the careful selection of patients, with the exclusion of those who fail to measure up to an exacting history and physical examination, supported in certain cases by myelography.

The best results are obtained when the offending disk is removed during a period when the patient is having severe pain.

The prognosis under conservative management, is uncertain because of the high recurrence index. The outlook following an accurate diagnosis and an early appropriate operation is excellent. The results depend to a considerable degree on the question of compensation and pending litigation.

Comparatively few patients who have ruptured intervertebral disks ever recover a completely normal back that will withstand any kind of stress and strain. About three-fourths of those patients who are operated upon ultimately obtain a satisfactory result.

Removal of an unequivocal disk lesion will fail to relieve the symptoms of the patient who has a major mental component in the form of deep-seated fear, anxiety, and guilt feelings. Unfortunately some surgeons on recognizing the presence of a psychic deviation from the norm exclude such patients from the benefit of surgery. Recognition, frank discussion and attempted correction of the psychic factors accompanied by properly-timed, adequate surgery will yield brilliant therapeutic results in many otherwise hopeless situations (Barr).

Osmond-Clarke found that conservative treatment produced satisfactory results in approximately 80 per cent of his patients who had symptoms and findings of disk lesions.

If those patients who are incapacitated by involvement of the components of the sciatic nerve are the only ones selected for operation, relief of symptoms can be anticipated uniformly.

Recurrence of the pain and disability after the patient has resumed active labor is a real possibility. The patient whose job does not require bending and lifting may return to work within two weeks after discharge from the hospital.

Barr wisely warns that, "We must not lose sight of the fact that the irreducible unit of treatment is the individual and that we treat patients not diseases. One, therefore, strives to know what kind of disease the patient has, and also what kind of patient has the disease."

Barr finds there are as yet no clinical methods by which one can accurately determine the exact nature and extent of the pathological changes present

in persons with low-back and sciatic pain due to intervertebral disk lesions The most careful analysis of signs, symptoms, and laboratory findings in a specific case scarcely allows one to hazard a prognosis When one considers the variations in selection of cases, methods of treatment, and accuracy of evaluation, the results of various reported series are remarkably similar Ytrehus reported 256 patients representing 2 per cent of the admissions to a general hospital, who had severe sciatic pain with a positive Lasegue's sign Obviously disk lesions, spondylolisthesis, spondylitis deformans, and other diagnostic entities were included Treatment consisted in complete bed rest, local heat, and sedation The average hospital stay was thirty-seven days On discharge, 47 per cent of the patients were free of symptoms, and most of the others were improved Two to eight years later, 220 (86 per cent) of the patients were re-evaluated Of these 34 per cent were at full work without symptoms, 37 per cent were at full work but had symptoms, and 29 per cent were at least partially disabled Thirty per cent had recurrences severe enough to require sick leave or re-hospitalization Boysen's results (431 cases) were in general similar to those of Ytrehus She noted that after the age of forty-six relapse is rare Colonna has carefully studied a group of patients who clinically and by myelogram had symptoms of an intervertebral-disk lesion Following "conservative" treatment 29 per cent were found to be symptom free at end-result study, while 71 per cent had some residual disability, and 57 per cent were intermittently completely disabled

Most observers agree that about 30 per cent of patients with disk lesions will recover spontaneously from their first attack, and many of these will have no further symptoms for long periods of time Barr finds that those patients who have had two or more recurrences are unlikely to have either prolonged or complete remissions and are faced with the choice between restriction of activities with partial invalidism and attempted relief by operative methods

The variability of the clinical course in patients with disk lesions makes an analysis of results of treatment extremely difficult, and all statements must be tentative

The size of the myelographic defect if one is present, bears little relationship to the end-result Barr has observed cases of spontaneous recovery in which the myelographic defect has remained unchanged

Grant and his associates found no relationship between increased narrowing of an intervertebral space and the clinical result He found that the factors of age, trauma or type of occupation bore a relationship to this type of injury

Young found that lost or diminished achillis reflexes did not often return nor should a patient anticipate that paralyses will recover following successful removal of the offending mass

Cases with an extruded disk offer the best prognosis

The removal of a steel splinter from one's eye is imperative and urgent but it is not a guarantee against future trouble in the same or the other eye There is an analogy here with disk protrusions A person may consult a dentist because of a specific tooth disorder but the dentist may find more than one tooth involved

The results of operation should be evaluated on the basis of the following criteria

1 Relief from backache
2 Relief from extremity pain
3 Residual disability
4 Ability to return to previous occupation
5 Ability to return to any occupation
6 Physical examination

Reflexes	Hypesthesia
Lasègue Test	Muscle Power

There will always be some surprises and disappointments

There will always be some partial failures

There will always be some total failures

The "ordinary" backache is cured *between* attacks

A disk syndrome is cured *during* an attack

The best results are obtained in patients with large protrusions, as in full-blown sciatica, because the protrusion is easily diagnosed and eradicated (Burns)

The outlook is best in completely extruded sequestrated disks In cases of a slight bulge, the relief is not so complete Where nuclear material remains the outlook is unfavorable

I cannot agree with the statement that neither the age of the patient nor the duration of his symptoms affect the prognosis Nor can I subscribe to the belief that results are as good after many attacks as they are after a few

Moore and Cook find that if nerve root pressure is allowed to exist for six months or longer, the changes may become irreversible Pain may be relieved but reflex changes, sensory disturbances and loss of motor function with muscle atrophy, may continue indefinitely

Adson emphasized the compensation aspects of the disk problem He advised careful selection of cases for surgery There is considerable difference in the prognosis between compensation and private cases

In the military services a comparison of enlisted men and officers reveals a striking difference in degree of both complaints and prognosis

O'Connell's excellent results must be attributed largely to operative skill and experience, but also in part to the careful selection of cases Burns believes the higher the surgeon's threshold to operation, the better will be the results Where a wider range of cases is included the results will not be so good

Barr reports about 90 per cent of properly selected and treated cases are either cured or greatly improved There is a failure rate of 10 per cent even in skilled hands Approximately 40 per cent of patients have some degree of residual disability

Results of surgical treatment are not perfect in anyone's hands Cures in 100 per cent of all cases is a figment of the imagination (Burns)

The results of simple removal of a herniated disk are satisfactory Operation on a protruded disk is followed by good to fair results in about one-half of the persons operated on

By the use of bilateral leg traction and rotatory manipulation under anesthesia, Mensor and Holscher secured 80 per cent of satisfactory results in a relatively large series of cases. Less than 10 per cent of their series were subjected to operation.

Holscher's patients obtained immediate relief from pain following manipulations, and had a much shorter period of convalescence.

In some cases, an exaggerated lordosis is conducive to the development of symptoms. The back weakness predisposes to rupture of a disk with herniation of the nucleus pulposus. Operation to remove the disk does not cure the back weakness and therefore in many cases does not relieve the patient of pain.

A survey of a large number of insurance cases operated on in many well-known clinics throughout America reveals that about 60 per cent had postoperative pain and disability after removal of the ruptured disk. This finding coincides with Moore and Cook's study that 60 per cent of the patients with typical disk symptoms do not have ruptured disks.

In most cases the acute symptoms subside under conservative treatment. In about 10 per cent, the symptoms are intractable and severe enough to warrant operative treatment.

The results of operative treatment are not always satisfactory, but they compare favorably with those of other surgical procedures.

The widespread reluctance to recommend operation, even in the more severe cases, was born of the many failures, and even occasional disasters, inevitable in the exploration and development of a comparatively new field of surgery.

In his first 26 operations O'Connell failed to find a protrusion nearly as often as he did subsequently. He now draws a "blank" in only 1 in 40. The experience of many other surgeons has been similar. There is no necessity to acquire experience the hard way, because any surgeon who wishes can obtain the necessary training.

Burns feels that the fear of causing paralysis has been grossly exaggerated.

It is the general consensus of the experts who treat rupture of the intervertebral disk that such patients regardless of treatment or present state of good health should refrain for at least two years from acute back bending, heavy weight lifting, straining and protracted walking or standing. It is necessary for these patients to know at all times that the ruptured intervertebral disk has been removed to alleviate symptoms and not to present them with a new back. The mere fact that the ruptured intervertebral disk has occurred is proof positive that the back is a weak one and should be so treated.

CHAPTER 58

TREATMENT OF THE DISK SYNDROMES

Conservative Measures and Surgery

"SELECTION of proper treatment requires an accuracy of knowledge which is still in many instances beyond one's professional abilities. Trial and error, empiric and pragmatic methods are common practice, and must in fact continue in use, till more scientific data are available" (Barr).

The treatment of the disk syndromes includes non-operative, operative and post-operative measures. Most surgeons advise a trial period of conservative treatment, unless there is gross evidence of damage to a component of the central nervous system, or until repeated episodes of severe pain require strong medicine or hospitalization or if disability has supervened, *i.e.*, a nerve deficit.

A period of observation and conservative treatment usually will indicate whether there is an underlying lesion of the spinal cord or of a nerve root, which must be relieved surgically. In most patients, either under conservative treatment or spontaneously, the acute symptoms will disappear or subside to a point where they are tolerable. The natural course of the disorder is to improve. Conversely, there are situations where it is more harmful to withhold than to perform surgery.

The most important objectives are interruption of the pain circuit and dispersion of muscle spasm. Many patients should be treated conservatively. However, the recurrence index is very high, therefore, operation is often the more conservative.

Non-operative Treatment.—Measures designed to relieve acute attacks of low-back and radicular pain include rest, heat, analgesics and local procaine block. Breaking up the vicious cycle of pain and muscle spasm is the target of conservative therapy.

Although the effects of myanesin by vein may not be prolonged, Schlesinger found that the muscle relaxation gained in minutes may amplify the response to other forms of therapy. The degree of response to the drug is of value as a diagnostic and prognostic test.

When pain and limitation of straight leg raising are rapidly improved after injection and this relief persists for hours, favorable results of prolonged conservative treatment usually can be predicted. However, when complete dissolution of the muscular splinting does not increase the range of straight leg raising or actually decreases it, the prospective results of even long term conservative therapy are poor.

In a large series of cases studied by this method at the Neurological Institute the test proved *quite useful* in filtering out early, those instances in which conservative treatment was destined to fail. At operation, these cases invariably showed large disk protrusions incarcerating the root in such a way as to preclude relief of compression by conservative means.

Although every patient should have the benefit of a period of conservative management, Moore and Cook feel that unnecessary procrastination may convert an emotionally unstable individual into a confirmed neurotic

Barr recognizes certain important factors

(a) *Time lapse* The pathological process must run its course

(b) *Favorable influences* The low-back structures should be protected from strain and irritation by bed rest, braces, corsets, strapping and plaster casts

(c) *Unfavorable influences* A large lesion causing severe root pressure recurring trauma, excessive reflex muscle spasm, mechanical instability of the vertebral column and accelerated degenerative process of disks, articular facets, and contiguous ligamentous structures are factors which may prevent recovery under conservative treatment

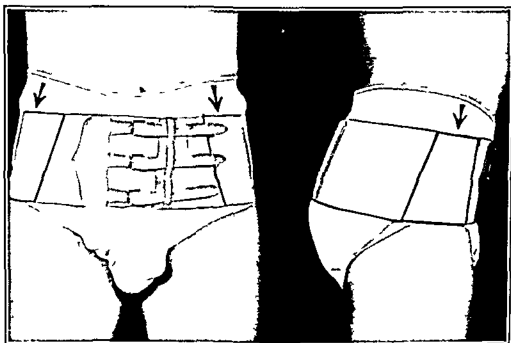


Fig 358 —Lewin polo belt (arrows indicate position of heavy elastic webbing)

Barr finds that ill advised or improperly applied treatment may make the patient worse instead of better Psychic trauma may also be inflicted by the physician who is inept He referred to these as iatrogenic factors

Indications for Conservative Treatment —The initial episode of pain is treated by conservative measures over a reasonable period of time since a considerable proportion of patients with lumbar disk disorders will be relieved without operation

Mild cases of herniated nucleus pulposus are prone to remissions and may not require surgical treatment Myelographic studies will usually confirm the diagnosis in cases lacking the essential clinical findings But pantopaque should be used only in those patients who are sufficiently incapacitated to justify surgical removal of the lesion if a positive diagnosis of herniated nucleus pulposus is made

The reader is advised to review the basic principles of treatment of back disorders in Chapter 12

A therapeutic test of conservative treatment includes

Rest in bed
Rigid mattress
Fetal posture in bed—posture of comfort
Ethyl chloride sprays
Analgesics
Sedatives
Tolserol—mephenesin intravenously
Curare and stretching
Elimination of trigger points by procaine injections
Pelvic strapping with adhesive tape
Traction
Corset
Brace
Polo belt with elastics
Crutches
Cushion pads in shoes
Tilted heels for shoes
Physical therapy
Manipulation
X-ray therapy

The trouble may be attacked from one or more of the following points of view

1 Posture in bed—Bed board or fetal posture, in a chair, at stool
2 Mechanical—Balance pelvis if necessary, balance feet and legs
3 Medicinal—Salicylates, Demerol, Tolserol, Butazolidin Curare Codeine
4 Supportive—Adhesive strapping, belt, brace, plaster cast crutches, 2 canes cushion feet with pads in shoes, support feet, if indicated, modify shoes, if indicated
5 Protective—Against further injury
6 Physical therapy—radiant heat, massage, inductotherm, ethyl chloride spray
7 Traction should be tried and continued, if helpful
8 Injections
9 Manipulative—Aimed at relieving pain, spasm, impingement or subluxation
10 Radiological—For pain and muscle spasm
11 Psychological—Very important in every case

Manipulation —Manipulation may be effective in the readjustment of a beginning herniation My experience indicates that the signs and symptoms produced by a protrusion may be reduced, rather than the reduction of a protruded disk Cyriax advocates manipulation in early cases

OBESITY

Persons with disk degeneration often have backache in association with an increase in weight The condition is usually relieved by reduction of weight plus a corset

Reduction of weight is imperative in some cases An optimal diet is advisable for every person Water retention is important in many

PROTRUSION OF AN INTERVERTEBRAL DISK DURING PREGNANCY

In cases of a disk syndrome appearing during pregnancy, the measures to be taken are (1) avoidance of stooping, lifting or straining (2) wearing of a lumbosacral support and a good maternity corset

Decisions vs Incisions —Practically every authority advises one session of conservative treatment The notable exception is Delitala who advises surgery only Dandy went so far as to say that when a patient has enough pain to consult a physician, he should be operated on Surgical intervention should not be advised for any patient until adequate conservative treatment has been given a reasonable trial

Barr maintains a conservative attitude toward disk surgery, reserving it for those patients whose symptoms have failed to subside under conservative treatment or who have evidence of severe root pressure, or who have had several recurrences He prefers to operate during an acute attack

Interesting and Conflicting Viewpoints —The questions to be answered are (1) To make a myelogram? (2) To operate or not to operate? (3) When to operate? (4) What to do? (5) To fuse or not to fuse? *a* If you are going to fuse, when should you fuse? *b* How much should you fuse?

At medical meetings most of the speakers extol the virtues of conservative treatment, but strangely enough, many of them report large series of operative cases A conservative attitude should be maintained regarding surgery of a herniated disk, for in many early cases improvement occurs without surgical interference, however, with or without operation, these patients present some permanent disability which requires back protection Persistence and severity of symptoms are the criteria for advising surgery

Mid-line protrusions differ from lateral protrusions A mid line protruded disk presents an emergency situation An operation on a herniated disk is like a tonsil operation in that it is like another attack to "end all attacks"

The most important question to decide, is, which patients should not be operated on The patient can usually decide when conservative treatment ceases to be beneficial and will usually be receptive to surgical treatment, when he gets to the stage where he is not able to do the things that he enjoys doing even though he is able to do the things that he must do

There are certain *cardinal indications that Sheldon recognizes for surgical treatment* The first is the presence of intractable pain The second is relative certainty of the diagnosis of low-back and sciatic pain Low back pain alone is not a sufficient indication for a surgical procedure There should be some objective neurological findings, the most important of which are (1) absence of the Achilles reflex indicating first sacral nerve root involvement, and (2) weakness of extension of the great toe, indicating involvement of the fifth lumbar nerve root Involvement of both nerve roots often occurs if a disk is completely extruded through the posterior longitudinal ligament Weakness in hopping on one foot is generally associated with extruded fragments

Indications for Operation —The chief indications for operation are (1) Failure of adequate conservative treatment (2) Repeated attacks of severe pain (3) Disability Burns and Young find that in "the run of the mill" cases of backache or sciatica, about 1 in 40 needs operation

Love emphasized the fact that not all patients who have low back pain and sciatic pain require operation The patient however, who is having sufficient pain and disability to interfere with his work his hobbies, or his recreational activities deserves serious consideration If in spite of a well planned and well-executed course of conservative therapy, the condition of the patient becomes worse if he is unable to carry on his usual activities, or if muscle atrophy or neurological signs develop, then surgical investigation is in order

Junge s indications for operation are so strict that only every fifth case of his clinically diagnosed prolapsed disks comes to operation

The surgeon must decide between conservative management and a surgical procedure. Good results from surgery require mature surgical judgment, precision surgery, and attentive follow up care.

Indications.—Only those patients who are incapacitated by involvement of the components of the sciatic nerve should be operated upon.

In spite of the fact that many patients with severe persistent sciatic and back pain recover spontaneously without the aid of surgery, there is a large group who improve but do not fully recover. Many patients who have suffered year after year, from intractable sciatic pain without showing evidence of a progressive lesion probably have had ruptured intervertebral disks with herniation of one or more nuclei pulposi.

There comes a time in most cases where the surgeon must decide two questions: When to operate and what to do when he does operate?

Armstrong's *indications* for operation are:

1. Failure of conservative treatment.
2. A massive nuclear retropulsion with cauda equina pressure.
3. The effect of severe persistent interference with root function.

His *contraindications* to operation are:

1. Inadequate conservative treatment.
2. Doubtful diagnosis.
3. A neurotic patient.

Never use any undue influence to persuade any person to be operated upon. The patient is usually a good judge of his pain and must make up his mind about operation. If the surgeon does not use undue persuasion, there will be fewer recriminating comments later (Millikan). One should never fail to observe danger signals that indicate a postponement of surgery.

If, after a careful study of a case, Noyes and Hunter are convinced that the patient is honest in his complaints and is chronically disabled, they do not hesitate to do an exploratory laminectomy.

The weakness and derangement that were responsible for the rupture of a disk may persist in spite of treatment, so that the surgeon soon finds himself working for the relief and palliation of disabling and crippling symptoms. One does not always achieve a complete cure by removing an abnormal disk, however, relief of symptoms can be uniformly anticipated.

As the experience of Walsh and Love with protruded intervertebral disks in all regions of the spinal column increased, and, as they learned more about the symptoms and signs of protruding cervical disks, their incidence of operative intervention increased to approximately 10 per cent.

Does the Patient Desire an Operation?—The best surgical results are obtained in those patients whose symptoms are severe and who spontaneously request an operation. Burns and Young have a good working rule: "Let the patient decide."

The study carried out by Delitala and Bonola is very instructive. According to Delitala, the only appropriate treatment of a herniated intervertebral disk is surgery. All other methods of treatment provide only temporary relief. The longer surgery is delayed, the more the consequences are aggravated because of the pressure exerted by the disk on the nerve roots. In the presence of herniation of a disk, with its characteristic acute subjective and objective symptoms, Delitala considers early operation to be imperative.

Author's Comment.—I consider Delitala's point of view very valuable because he has had as large a "clinical control" series as anyone in the world. He "inherited" an enormous volume of patients who had been treated over a period of years by all approved conservative measures, by Putti and his associates.

Burns and Young claim that they maintain a high threshold to operation. They feel that restricting operation to patients with severe symptoms has two advantages: the lesion is more clearly identified and eradicated, and if the cure is not complete, it will at least compare favorably with the preoperative condition. Burns finds that if the operation is performed during a quiescent interval, no matter how severe and frequent the attacks have been, the protrusion may be missed. He believes that protrusions do reduce spontaneously.

Spurling cautioned against operating during a remission. Failure to observe this precaution is one of the most common causes of negative explorations.

In 20 per cent of cases, Key considers operative removal of the offending disk an elective procedure. If the pain is intolerable or if it disables the patient, to a point where it seriously interferes with his work or pleasure or comfort, and if this pain is not relieved by conservative treatment, then operation should be advised.

In most patients who are operated upon primarily for pain, Mixter considers the operation definitely one of election and of the patient's choice. The patient has to make a decision, on the basis of the pain he is suffering, as to whether he is willing to continue with the pain or whether he wants to have something done about it. The operation should not be urged upon any patient. An operation should be performed while the patient is having pain and not during a remission. Motor weakness, however, should be considered a definite emergency and the patient should be operated upon at once. Patients who have persistent footdrop and particularly those who have a transverse lesion of the cauda equina should be studied carefully. If the motor weakness is permitted to remain for a considerable time, the muscle power may never return. Some of Mixter's patients who had had footdrop for over six months never recovered muscle power.

A good rule to follow is: Operate during an attack. A corollary is: reserve the decision to operate until requested by the patient, and only after the situation has been thoroughly explained to him.

The operation is not often a lifesaving procedure. Ehni considers:

1. The degree of disability present during an attack.
2. The duration of attacks.
3. The length of the intervals between attacks.
4. The total duration of the illness or disability.
5. The age of the patient.
6. The response or lack of it, to conservative treatment.
7. The attitude of the patient toward his pain.

Unilateral and occasionally bilateral sciatica, complicating low-back disability and refractory to conservative treatment, is regarded by Spurling and Grantham as the only specific indication for disk surgery.

Busch believes that operation is indicated in cases with persistent objective signs of radicular compression with sensory or motor loss. The operative indication becomes absolute in cases with extensive compression and spinal block.

Harmon's decision for surgery is based chiefly on the degree of incapacity of the patient and his failure to secure relief from adequate well supervised non-operative treatment.

A myelographic defect is considered as a diagnostic and localizing sign to be interpreted for each individual rather than a surgical mandate.

O'Connell finds that excision of a lumbar intervertebral disk protrusion is required in only a small proportion of patients who have the lesion.

Pennybacker reserves operation for cases which are resistant to treatment, or in which there are frequent recurrences.

R. H. Young advises operation in the following situations:

1. Persons with severe pain who have made no practical improvement after three weeks in bed.

2. Patients with repeated attacks sufficiently frequent and disabling to force them to request operation.

3. Patients with chronic lame backs who are unable to do the work they want to do.

Pouyanne's indications for operation for sciatic pain are failure of other methods of treatment and severe recurring pain. In exceptional cases, when the disk cannot be removed, he performs a nerve root resection.

With well marked physical signs indicating a protrusion, Young advises that the disk be exposed and removed. He requires that the patient have physical signs, or *x*-ray changes, or both, and that the symptoms shall have been present for some time. The passage of time will diminish the possibility of error in diagnosis.

Burns objects to carrying conservative treatment to the limit of the patient's tolerance. He objects to operative procrastination until "mental and physical exhaustion" have supervened.

Differences of Criteria for Evaluation and Opinion.—One surgeon operates if the Lasegue test is positive. Another begins to wield the scalpel if one knee jerk is diminished. One operates if one Achilles jerk is gone. Another operates if there is erector spinae muscle spasm. Still another requires only a list of the torso. One man says "never operate", another says "always operate." This adds to the confusion of the general practitioner.

The surgical treatment of a herniated nucleus pulposus is fundamentally a procedure to relieve pain. In spite of the fact that many patients with severe persistent sciatic and back pain recover spontaneously without the aid of surgery, there is a large group who become very much better, but do not fully recover. Some of these become "chronic back cases."

Dandy claimed that merely opening a traumatized disk effected relief or cure. Armstrong says that there is no other major group of cases, in which a major surgical procedure has afforded so much satisfaction to both patient and surgeon.

Every candidate for operation on a lumbar disk should have a complete orthopedic and neurologic investigation before the operation is discussed

with the patient If surgery has been advised and the advice has been accepted, myelography should be performed in every case in which there is any doubt as to the diagnosis or location of the ruptured disk or disks

By appropriate tests, the differential diagnosis can usually be made, between a herniated nucleus pulposus and mechanical pressure due to an unstable spine If by surgery and by no other means, a young person can be made normal and an older person comfortable, Moore and Cook advise operation It is a conservative and not a radical procedure Conversely, conservative treatment that seriously alters one's life, is very radical, in so far as the patient is concerned

Many surgeons claim "There is no evidence that laminectomy weakens the back" This statement has been seriously challenged

In Summary —Advice to Surgeons —(1) Do not operate between attacks (2) Do not operate unless the patient literally "begs" for it

Seventy-five to 80 per cent of the patients treated for ruptured disks responded adequately to conservative treatment and did not require surgical intervention Of those operated upon about 60 per cent were cured, in about 30 per cent the result was satisfactory In about 10 per cent of cases the patient received little or no benefit from the operation and in an occasional case, he had more pain than before the operation

CHAPTER 59

SURGERY

THREE important points in surgical treatment are (1) The complete removal of affected disks (2) The recognition of multiple disks (3) The recognition of small concealed disks

If the suspected disk appears normal one should examine the adjacent interspaces When a definite lesion is seen the disk is incised and lightly curetted, and the loose material is removed

In patients with bilateral symptoms, Myers advises a complete laminectomy with bilateral exposure of the suspected interspaces The patients are successfully treated by a complete laminectomy with transdural removal of the herniated disk O'Connell favors a limited interlaminar approach Armstrong removes the spinous process and most of the lamina in order to obtain a comprehensive view The dura should not be opened unless there is some residual radiopaque oil

One should inspect the disk spaces below L4 and L5, even though a protrusion has been found at either one If no disk is found below L4 or L5 one should explore L3 If the patient had radiation of pain to the groin one should explore up to L2

Dense perineural and epidural adhesions between a nerve root and its dura and the posterior part of the spinal canal can produce sciatic pain They are due to previous surgery or infection

In about 10 per cent of cases there is a protrusion or a lesion in more than one space It is generally agreed that it serves no useful purpose to cut into a normal disk (Burns and Young) Most surgeons remove disk herniations by the interlaminal approach sometimes aided by the removal of sections of bone from the adjacent margins of the lamina bounding the involved space Falconer advises radical removal of the disk from both sides of the theca

Spurling finds that thorough curettement of the disk reduces the number of recurrences This is in contrast to the experiences of Love and Adson

In attempting the complete removal of a degenerated disk a soft copper curette which lessens the danger of penetrating the anterior spinal ligament Exploration should include visualization of the fourth and fifth lumbar and the first sacral nerve roots If one has failed to find adequate explanation for all signs and symptoms a complete operation must be performed exploring both sides and possibly opening the dura

Operation for removal of a ruptured lumbar intervertebral disk can often be accomplished without destruction of a lamina or articular facets Spurling and Grantham do not open the posterior rim of an annulus fibrosus unless a complete or incomplete tear can be demonstrated in it by inspection or by palpation with a blunt instrument A bulging disk should not be opened unless it impinges upon a nerve root

Cloward believes that simply removing the herniated fragments of an intervertebral disk without immobilizing the joint, disregards the primary pathology. Likewise, fusion of the spine without a thorough investigation and decompression of the involved nerve root cannot be expected to relieve the patient of radiating pain in the lower extremities.

The number of complete and permanent cures obtained by the vertebral body fusion operation are 30 to 50 per cent higher than the 'cures' after simple removal of the disk. This is attributed to the fact that vertebral body fusion eliminates the complaint of low-back pain which is the most frequent disabling postoperative symptom following simple disk removal.

The procedure is actually three operations in one: removal of the bone grafts, laminectomy and removal of an intervertebral disk and lastly, the spinal fusion.

The present method of facilitating the operation is to 'break' the operating table which affords better access to the area. This tends to aggravate hemorrhage.

Cloward designed and evolved a procedure whereby, after removal of a part of an intervertebral disk including the cartilaginous plates, a full thickness bone graft obtained from the crest of the patient's ilium was driven between the bodies of the vertebra. This procedure was successful from the beginning in giving the patients lasting relief of their symptoms. Since 1944, almost every patient having a ruptured disk whom Cloward has operated upon has been treated by vertebral body fusion. The operative technic has been gradually improved over the years. The operation consists of a subtotal removal of the intervertebral disk from both sides of the dural sac and replacing it with four or more large bone plugs. A mechanical fixation of the intervertebral joint is thus effected immediately.

Love advises that the surgical removal of any space-occupying intraspinal lesion should be so planned and executed as to cause the minimum of disruption of normal structures and thus facilitate restoration of the patient to his usual activities with a minimal loss of time.

Love's operative technic has been *steadily improved and simplified* until at the present time the entire procedure is accomplished extradurally, removing only a small notch of bone from one side of the lamina, or as in many instances removing the disk through the interlaminar space without removing any bone.

There are always two component parts of a ruptured disk that are responsible for the patient's symptoms: (1) the necrotic interior of the disk under pressure from edema which causes the backache, and (2) the protrusion upon or adherence to the emerging spinal nerve which causes the sciatica. It is essential that the interior of the disk be opened so that its non-viable contents may be extruded through the opening. This is necessary to relieve the symptoms since a large protruding disk may be withdrawn without effecting a cure unless the interior is opened.

The chief types of surgical procedure are: Exploration, arthrodesis exploration and primary fusion, secondary fusion.

One should start the operation with the objective of exploring below L4 and L5, unless sufficient trouble has been found below either to explain all the symptoms and findings.

Barr ascribes the greatest single advance in the treatment of sciatic pain to the development of a simple, safe operative method of relieving nerve-root pressure by removing protruded disk tissue Approximately 80 per cent of patients with this syndrome are relieved of acute pain and restored to satisfactory functional ability

Three important advances have improved and simplified the operative treatment Originally a bilateral laminectomy was performed and the disk was removed intradurally Mixter and Barr removed disks extradurally by the bilateral approach Semmes and also Love in 1939 reported their removal by hemilaminectomy and by removing only a notch of bone from a lamina

In 1940 Love introduced his operative technic of exposing and removing disks without sacrificing any bone He removed a high percentage of ruptured disks through the interlaminal spaces His technic is the acme of perfection

Cloward finds that with recent development of more efficient methods of hemostasis, including the improved electrical coagulation instruments, fibrin foam and gelatin foam with thrombin, the horizons of neurosurgery have been extended considerably Lesions such as tuberculous abscesses and granulomas, as well as tumors and cysts, and even large arthritic spurs situated anterior to the dural sac, at almost any level are now readily attacked by the extradural approach

Gelfoam and oxycel are very useful The cautery is practically indispensable The aspirator is indispensable Bone wax is effective in controlling hemorrhage

Postoperative hemorrhage with resultant pressure on the spinal cord must be avoided The control of hemorrhage is accomplished by adrenalin in the local anesthetic, sponges of various sizes and shapes, electrical coagulation, silver clips and small pieces of muscle (like postage stamps) under pressure sponges Mechanical aspirators are indispensable in maintaining an unobstructed dry field I have often used two aspirators as retractors to visualize the affected spinal nerve and the offending disk

Cloward's vertebra spreader and his self-retaining dura and nerve retractor should be very helpful

The surgical treatment of herniated nucleus pulposus is fundamentally a procedure to relieve pain and spasm Armstrong's present operative technic has been evolved over a period of years during which time he has operated on over 1,000 patients He credits his positioning of the patient and his approach to Burns and Young He employs the lateral posture of the patient The surgeon sits on a stool facing the patient

Before Operation —Precision Aids in Localization —There are precision tests in localizing intervertebral disk lesions and determining the specific interspaces involved These should be reviewed in every case the day before operation In addition, on the day before operation, one should inject 1 cc of methylene blue into the skin at the level of the 4th lumbar intervertebral disk and expose a lateral roentgen film The film should be in the illuminated box in the operating room during the operation This marker helps in identification orientation and localization of the lesion during the operation

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The number of complete and permanent cures obtained by the vertebral body fusion operation are 30 to 50 per cent higher than the 'cures' after simple removal of the disk. This is attributed to the fact that vertebral body fusion eliminates the complaint of low-back pain which is the most frequent disabling postoperative symptom following simple disk removal.

The procedure is actually three operations in one: removal of the bone grafts, laminectomy and removal of an intervertebral disk and lastly, the spinal fusion.

The present method of facilitating the operation is to 'break' the operating table which affords better access to the area. This tends to aggravate hemorrhage.

Cloward designed and evolved a procedure whereby, after removal of a part of an intervertebral disk including the cartilaginous plates, a full thickness bone graft obtained from the crest of the patient's ilium was driven between the bodies of the vertebrae. This procedure was successful from the beginning, in giving the patients lasting relief of their symptoms. Since 1944 almost every patient having a ruptured disk whom Cloward has operated upon has been treated by vertebral body fusion. The operative technic has been gradually improved over the years. The operation consists of a subtotal removal of the intervertebral disk from both sides of the dural sac and replacing it with four or more large bone plugs. A mechanical fixation of the intervertebral joint is thus effected immediately.

Love advises that the surgical removal of any space-occupying intraspinal lesion, should be so planned and executed as to cause the minimum of disruption of normal structures and thus facilitate restoration of the patient to his usual activities with a minimal loss of time.

Love's operative technic has been steadily improved and simplied until at the present time the entire procedure is accomplished extradurally removing only a small notch of bone from one side of the lamina, or as in many instances, removing the disk through the interlaminar space without removing any bone.

There are always two component parts of a ruptured disk that are responsible for the patient's symptoms: (1) the necrotic interior of the disk, under pressure from edema which causes the backache and (2) the protrusion upon, or adherence to the emerging spinal nerve which causes the sciatica. It is essential that the interior of the disk be opened so that its non-viable contents may be extruded through the opening. This is necessary to relieve the symptoms since a large protruding disk may be withdrawn without effecting a cure unless the interior is opened.

The chief types of surgical procedure are: Exploration, arthrodesis, exploration and primary fusion, secondary fusion.

One should start the operation with the objective of exploring below L4 and L5 unless sufficient trouble has been found below either to explain all the symptoms and findings.

Barr ascribes the greatest single advance in the treatment of sciatic pain to the development of a simple, safe operative method of relieving nerve-root pressure by removing protruded disk tissue Approximately 80 per cent of patients with this syndrome are relieved of acute pain and restored to satisfactory functional ability

Three important advances have improved and simplified the operative treatment Originally a bilateral laminectomy was performed and the disk was removed intradurally Mixter and Barr removed disks extradurally by the bilateral approach Semmes and also Love in 1939 reported their removal by hemilaminectomy and by removing only a notch of bone from a lamina

In 1940 Love introduced his operative technic of exposing and removing disks without sacrificing any bone He removed a high percentage of ruptured disks through the interlaminal spaces His technic is the acme of perfection

Cloward finds that with recent development of more efficient methods of hemostasis, including the improved electrical coagulation instruments, fibrin foam and gelatin foam with thrombin, the horizons of neurosurgery have been extended considerably Lesions such as tuberculous abscesses and granulomas as well as tumors and cysts and even large arthritic spurs situated anterior to the dural sac, at almost any level are now readily attacked by the extradural approach

Gelfoam and oxycel are very useful The cautery is practically indispensable The aspirator is indispensable Bone wax is effective in controlling hemorrhage

Postoperative hemorrhage with resultant pressure on the spinal cord must be avoided The control of hemorrhage is accomplished by adrenalin in the local anesthetic, sponges of various sizes and shapes, electrical coagulation, silver clips and small pieces of muscle (like postage stamps) under pressure sponges Mechanical aspirators are indispensable in maintaining an unobstructed dry field I have often used two aspirators as retractors to visualize the affected spinal nerve and the offending disk

Cloward's vertebra spreader and his self-retaining dura and nerve retractor should be very helpful

The surgical treatment of herniated nucleus pulposus is fundamentally a procedure to relieve pain and spasm Armstrong's present operative technic has been evolved over a period of years during which time he has operated on over 1,000 patients He credits his positioning of the patient and his approach to Burns and Young He employs the lateral posture of the patient The surgeon sits on a stool facing the patient

Before Operation —Precision Aids in Localization —There are precision tests in localizing intervertebral disk lesions and determining the specific interspaces involved These should be reviewed in every case the day before operation In addition, on the day before operation one should inject 1 cc of methylene blue into the skin at the level of the 4th lumbar intervertebral disk and expose a lateral roentgen film The film should be in the illuminated box in the operating room during the operation This marker helps in identification orientation and localization of the lesion during the operation

The operating table should have a "Kidney Break" Cushions and pads should be plentiful

In 1920 Dr Knowles, chief anesthetist at St Luke's Hospital, Chicago, designed a set of cushion pads which were very satisfactory

Frames that are helpful include Chandler, McBride s Convex Saddle Frame, Key and Odell s frame and an outrigger for cervical cases

Cloward places his patient on a sponge mattress, cut to fit the operating table The mattress is 4 inches in thickness, with a large hole in the center The patient s abdomen is placed over this hole One tries to avoid venous engorgement, stasis and increased bleeding from the epidural veins Cloward advises transfusion of from 1 to 2 pints, of whole blood during the operation



Fig 359 – Convex saddle frame Convex double bar is well padded by approximately 1 inch of felt covered by soft sponge rubber The surface covering is a plastic fabric laced in the undersurface so that it may be removed if necessary (Shorbe and McBride courtesy of Jour Bone & Jt Surg)

Notes on Procedure —Adrenalin added to the novocaine reduces the bleeding

The ligamentum flavum should be dissected in one piece

One should inspect all visible structures before closing the operative wound In order to be certain that everything is in order one should make a thorough inspection of the operative wound before closing The requirements for proper inspection are (1) Good retraction—but not forcible pressure (2) Good lighting

Kunlin anesthetizes the spinal cord by means of a direct local injection of novocaine

Many surgeons like Hoen Blount Herbert Burns Young, Armstrong O Connell and others favor the side-lying position during the operation Hoen places the patient with his painful side up The painful leg is straight,

the other is flexed Burns and Young find the side lying position has many advantages viz

1 It is the easiest way to flex the spine
2 The blood runs away from the depths of the wound
3 Less blood is lost
4 The patient is much less shocked than when lying on his face with pressure on his solar plexus
5 The operators can sit and be much more comfortable
6 Visitors can see more easily

The factors involved are Circulation, respiration congestion hemorrhage and edema

Identification of Specific Vertebral Targets During the Operation — When the vertebrae have been completely denuded one should positively identify the 5th lumbar vertebra by grasping several spinous processes with the jaws of heavy forceps and manipulating them to determine mobility The sacrum does not move

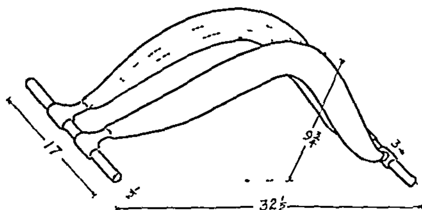


Fig 360 —Diagram of frame
(Shorbe and McBride courtesy of Jour Bone & Jt Surg)

Anesthesia —The choice of anesthetic should be left to the professional anesthetist Many favor spinal anesthesia Many surgeons including Spurling prefer local anesthesia for the preliminary stages of the operation When the affected spinal nerve is located and the offending disk is discovered a change is made to a gas anesthetic, for the highly technical part of the operation

Technic —One should always insert a chip of bone between each two sections of each vertebral articulation after removing cartilage, for contact compression and osteogenesis

One should leave all spinous processes intact wherever possible

Treat each apophyseal joint as though it were a sacroiliac or a calcaneocuboid joint

Fusion should be intra- or extra-articular or both

The basic prerequisite for fusion is the apposition of raw bleeding bone to raw bleeding bone and immobilization

The insertion of a bone block while the spine is in extreme flexion, followed by extension, locks the graft in position until fusion occurs

Metallic fixation has been practiced by Von Lackum, Carpenter, and Wilson King and Von Lackum inserted screws across the facet joints Judet, Michele and Sicard used acrylic prostheses Others use wire

One must beware of "crumbs" of bone that lie in contact with the spinal cord and nerves They grow and produce pressure, spasm, pain and limitation of motion

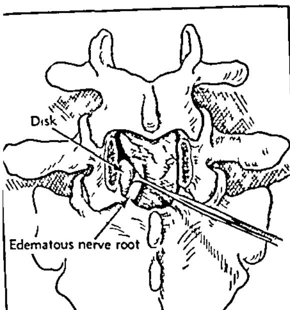
Cloward's instrument, which is used like a shoe horn, has removed the hazard of injury to the nerve root or cauda equina when the bone plugs are driven into the intervertebral space The pulling and hauling on the nerve root by a manual retractor has resulted in injury to the nerve roots, causing disagreeable post operative complications, such as urinary retention numbness of the foot and leg or even footdrop None of these complications have occurred since this instrument has been in use A total of 87 vertebral body fusions using banked bone have been performed by Cloward

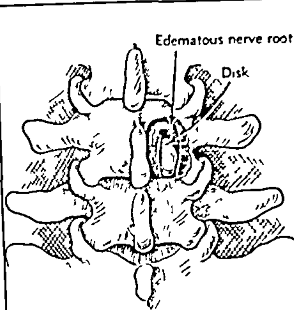
In the majority of good clinics, fusion versus non fusion is a very live question In many clinics, there is a trend toward the combined operation and in others the practice is diametrically opposed

The patient's ilium is the world's finest bone bank and it is usually readily available and adequate in amount Other sources of bone are (1) The patient's tibia, (2) a bone bank

Operation of Choice —The removal of a protruded intervertebral disk may become an operation of considerable magnitude Adequate exposure is essential Love finds it is usually not necessary to sacrifice facets or to do an extensive laminectomy Patients who have unilateral sciatic pain, due to a protrusion at the fourth or fifth lumbar interspace usually require unilateral reflection of the erector spinæ at the level of the protrusion When the ligamentum flavum is resected there usually is sufficient space through which the protruded disk may be removed, without the sacrifice of any bone The involved nerve root is retracted between the laminæ, and the fragmented disk tissue is removed In protrusions at higher levels or when there is marked narrowing of the interlaminal space, the margins of the laminæ must be removed In cases of bilateral sciatic involvement and those of backache only —usually due to mid-line protrusions—it is often necessary to shear off a portion of the adjacent spinous processes and of the laminæ and to remove the ligamentum flavum bilaterally as well as the interspinous ligament in order to obtain adequate exposure and to avoid trauma to the cauda equina while the protruded fibrocartilage is being removed At the Mayo Clinic the surgeons do not insist on complete removal of the disks

In the operation described by Love the spines and laminæ are stripped subperiosteally of their musculature At this point one of the most valuable instruments in spine surgery is a very wide, heavy periosteal elevator A set of these instruments varies from 1 to 2 inches in width The instrument made of one piece of metal, has a long heavy round or hexagonal handle The working end is bevelled and sharp The last one inch is not chrome plated A set of these was given to me twenty years ago by Dr D H Levinthal who designed them They facilitate de skeletalization of the vertebræ without danger because of their width which precludes puncturing tissues between the laminæ





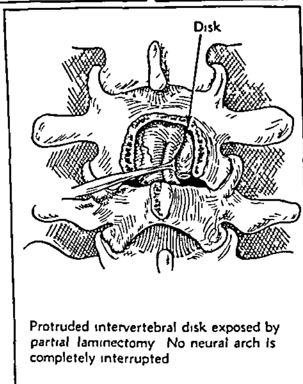


FIG 361 —Operative procedure for removal of protruded portion of an intervertebral disk by the technic of Love

The ligamentum flavum is then resected from between the laminæ of the involved vertebræ on the affected side. The nerve root and dural sac are retracted medially and the herniated disk is brought into view and removed. One should not hesitate to resect bone to obtain adequate exposure. Frequently the pulpy herniation is seen lying free in the spinal canal. Just as frequently, the herniation is partly in and out of the intervertebral space and must be gently teased out. If the posterior longitudinal ligament is not torn over the bulging hernia a cruciate incision is made in the dome of the herniation and the disk thus removed.

INSTRUMENT TO SEPARATE VERTEBRÆ TO FACILITATE REMOVAL OF HERNIATED INTERVERTEBRAL DISKS

In view of the decided advantage of performing the operation without removing bone Lewin introduced an instrument which will separate the vertebral laminæ and spinous processes. During the course of the operative procedure, even millimeters of extra space are helpful.

The instrument affords better visualization of the field for observation of an intervertebral disk, a spinal nerve or other structures. It facilitates the operative procedure and reduces the danger of injuring the tissues.

The mechanical principle involved is that of the automobile valve lifter, a jaw distractor or a plaster of Paris cast spreader. I. The handle is made of two bars with a connecting rod containing a nut within and another without the bars. II. The blades have a spreading mechanism and a "control" that maintains the degree of spread. The bone-engaging prongs are sharp because they must not slip. Adjustments must be gradual and precise. Release must be made slowly. The instrument is self retaining. The blades are angulated to clear the back muscles.

Technic of Use.—After complete skeletalization of the area to be explored the prongs are carefully inserted between 2 spinous processes and the 4 points are firmly engaged into the 2 laminæ to be separated. The handle is squeezed and the vertebræ are separated slowly and cautiously. When the desired distraction is obtained the handles are locked and entrusted to the care of an assistant. After the spinal part of the operation is completed the handles are slowly released and the bones resume their normal relations, especially the vertebral facets.

Figure 362 is that of an instrument which will separate vertebral laminæ and spinous processes. It was designed especially to facilitate removal of protruded portions of intervertebral disks without removing any bone. It affords better visualization of the operative field for observation of a disk, a spinal nerve or other nearby structures. It also facilitates the operative procedure. After complete skeletalization of the area to be explored, the blades of the instrument are inserted between two spinous processes and the four sharp points are sunk into the pedicles to be separated. The handle is squeezed and the vertebræ are slowly and cautiously separated. When the desired distraction is obtained, the handles are locked and entrusted to the care of an assistant. After the operation is completed the handles are released and the bones resume their normal relations. (NOTE: The reader will recognize the handle of a Goodall uterine dilator.)

Key and Lord advise that the lamina of the 1st sacral vertebra be exposed and identified. The first movable spinous process above it is the last lumbar vertebra. The Kerrison rongeur is used in removing buttons of bone from the lamina. Care must be exercised to avoid injury to the epidural veins. After the disk has been removed, any bleeding of epidural veins is controlled by cautery and gelfoam. They do not perform spine fusion after primary operation for the removal of a ruptured disk where no other pathology of the spine exists. They do perform spinal fusion in some cases of recurrent disk ruptures and in cases where an isthmus defect is present and is a factor in the causation of the back symptoms.

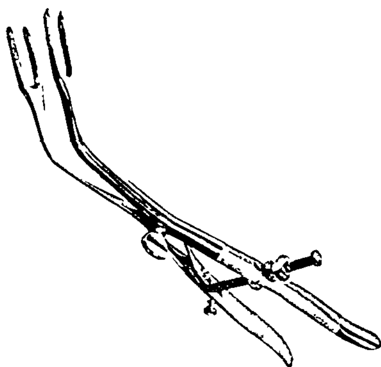


Fig 362 —Lewin's vertebral separator (Courtesy of V. Mueller and Company, Chicago.)

Key and associates operate under local anesthesia containing adrenalin. Freedom of the abdomen reduces respiratory effort, engorgement of the extradural veins, the likelihood of damage and extradural bleeding. One hour before the patient goes to the operating room, he is given three grains of nembutal and a quarter grain of morphine.

In the anesthetic room, the patient is placed face down over a large rubber-covered doughnut. The electrocoagulating unit pad is adjusted to the calf of one of the legs, and the table is then broken just enough to eliminate the lumbar lordosis. The Bovie and sucker are at the foot of the table.

The skin incision is made and the deep fascia is exposed, the bleeders are controlled by coagulation, and skin towels are applied. The operator palpates the spinous processes. Using a size twenty needle and $\frac{1}{2}$ per cent novocaine containing 3 drops of adrenalin to the ounce, the needle is dropped straight down alongside of a spinous process until the lamina is encountered, and about 5 cc. of novocaine injected at the spot. This is

repeated with each lamina that is to be exposed It is usually necessary to put more than 5 cc over the sacrum After the sacrum and lamina have been injected, the needle is directed laterally and the muscle is infiltrated When this is completed, about 20 cc of novocaine is injected beneath the deep fascia and into the muscle opposite the level to be exposed Care

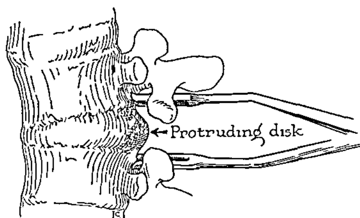


FIG 363 —Lewin s vertebral spreader in position Lateral view

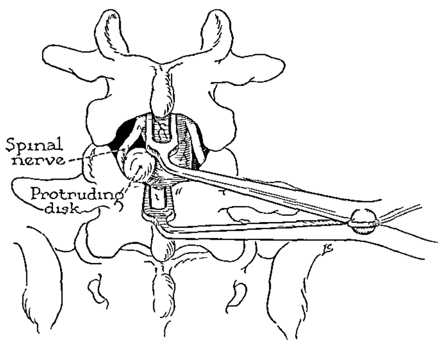


FIG 364 —Lewin s vertebral separator in position Visualization of protruded portion of intervertebral disk and its relation to nerve and bone

must be taken that the needle strikes the lamina and does not go through the ligamentum flavum Extradural injection of a large quantity of novocaine is quite painful One avoids putting novocaine into the theca

In the majority of cases it is necessary to remove some portion of the lamina above and below the space to be opened Therefore, at this stage using a 24-gauge needle and 2 per cent novocaine, the nerve root is injected

The deep fascia is incised and the muscles are stripped from the spinous processes and laminae. A self retaining retractor is then introduced. Remaining shreds of muscle and fat are then cleaned from the laminae and the exposed surface of the ligamentum flavum with a curette. This injection also helps to locate the disk space so that the operator knows from which side to remove bone in order to expose that space. Where there is a very small space, Key removes a portion of the lamina with a small gouge or a Kerrison rongeur. He removes a portion or all of an articular

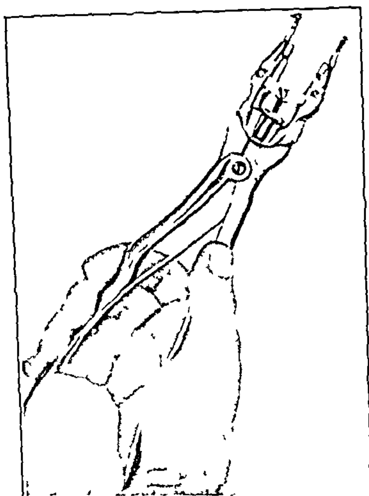


Fig. 365.—The vertebra spreader and retractor as used together. (Cloward, courtesy of Surgery.)

facet in order to obtain good lateral exposure. After adequate exposure is obtained, the extradural fat is peeled away to expose the nerve root, and the disk is then explored. A nerve-root retractor is inserted to retract the nerve medially. He uses a uterine curette with its tip hammered flat. Occasionally a completely ruptured disk is found upon retraction of the nerve root and can be lifted out in one piece. Most of the time it is necessary to incise the roof of the protrusion before it can be removed. To do this he uses a long handled tenotomy knife. After the roof has been incised, the disk material is removed with a pituitary rongeur. When the surgeon is satisfied that the involved nuclear material is well cleaned out,

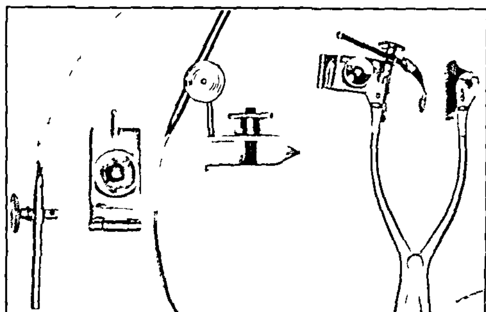


Fig 366 — Cloward's self retaining spinal dura retractor is attached to a modified Hoen laminectomy retractor by a large hinged clamp. The spatula is placed beneath the nerve root or cord, secured and held firmly in place by the swivel screw-clamp. (Cloward, courtesy of J Neurosurgery)

A B

Fig 367 — *A* Sawing ilium into bone plugs. *B* Four or more bone plugs used to replace one ruptured intervertebral disk. The large chunk of bone is converted into bone crumbs to fill the interlaminar defect. (Cloward, courtesy of Ann Surg)

the wound is thoroughly irrigated, the retractors are removed, and the wound is closed.

Dandy's Operative Technic.—The patient is under general anesthesia, prone, and in a flexed-spine position. Through a short longitudinal incision the spines of the vertebrae are exposed and the soft tissues dissected

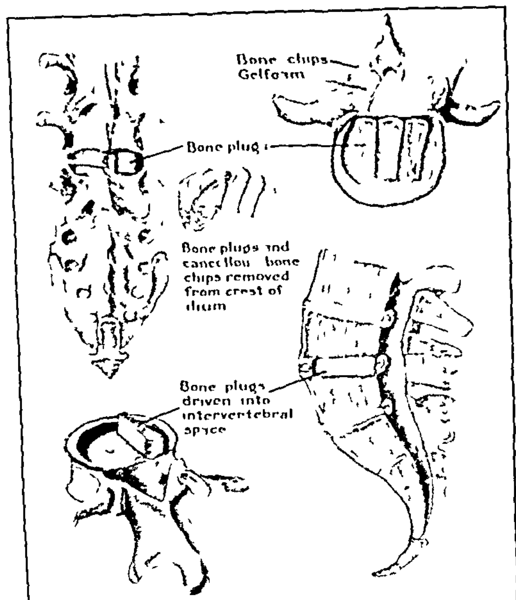


Fig. 368.—Technic of vertebral body fusion. Note wide exposure of spinal canal by removal of half of articular facets. Upper right drawing shows only gelfoam covering dura mater. The ligamentum flavum is preserved to protect dura mater. (Cloward, courtesy of J. Neurosurgery.)

subperiosteally and retracted to one side. The ligamentum flavum is cut from between the laminae over the suspected area to expose the canal. The nerve root is drawn aside and the intervertebral disk is examined. If extruded material is seen, it is removed. A herniation or a soft spot in the disk is incised by a tenotome. If a closed thin forceps can drop through the opening and on withdrawal shows flakes of material, the diagnosis of concealed disk is made. The opening is then enlarged.

One should remove the protruding cartilage and as much more as can be extracted from the depths of the necrotic interior of this disk Dandy insists that the interior of the disk must be treated by breaking up its contents with forceps For the concealed disks in which but little cartilage can be extracted, Dandy breaks up the interior of the disk with forceps The eventual cure depends on the removal of all necrotic material

Echer emphasizes the interlaminar approach to the spinal canal after bilateral stripping of the sacrospinalis muscle from the spinous processes and laminae and decompression of small intraspinal protrusions of intervertebral disks

Armstrong favors an approach by means of a hemilaminectomy with removal of one spinous process

Steindler prefers to be conservative in his laminectomy, that is, he removes as little of the arches as possible He advises that laminectomy should be followed by fusion of the spine

After doing this operation for two years, *i e*, 1944 and 1945 the possibility of using cadaver bone for the grafts, as prescribed by Inclan occurred to Cloward Two factors were responsible for considering the use of bone other than that obtained from the patient First, and most important, was the length of time required to perform the operation At least three and a half to four hours were required to obtain the bone grafts from the ilium do the laminectomy remove the disks and complete the fusion The second factor was the all-too frequent post-operative complaint by the patient of discomfort in the hip at the donor site In 1946, a method of preparation and preservation was worked out The bone bank soon became a reality *The first concern naturally was the sterility of the grafts* The extreme danger of an infection from a non-sterile graft inserted between the bodies of the vertebrae can be readily appreciated The second consideration was an attempt to keep the bone "alive", *i e* to preserve if possible the connective tissue cells and vascular bed within the bone upon which new capillaries could grow This would hasten the growth of new bone into and across the graft Cloward s technic which has been used successfully for over five years is as follows

Obtaining and Preparing the Extra Bone

A suitable cadaver is chosen Bone from a young healthy individual, in whom death was sudden by accident or otherwise is preferred The best source is from traffic fatalities The body is prepared and bone removed exactly as for a sterile surgical operation Two large blocks of iliac bone are immediately placed in a sterile basin with a lid and sealed on the outside with adhesive tape It is delivered to the bone bank immediately or placed in an ice box

SURGICAL PROCEDURE

What to do at Operation —Love removes only that part of the disk which is fragmented No free material should be permitted to remain If the surgeon loosens anything, he should remove it

Vigorous Curettage —Some surgeons advise vigorous curettage of the disk. Puncture of a vena cava may follow this maneuver. Some surgeons recommend scraping vertebral spurs and posterior vertebral margins. I look upon the latter procedure as potentially harmful because it is analogous to removal of spurs from the os calcis which may stimulate local osteogenesis. Bucy removes the herniated disk and the underlying loose disk substance with as little removal of bone as is necessary for an adequate exposure.

Care should be taken to preserve the articular facets and pedicles in order to avoid unnecessary weakening of the back. The small vertebral articulations should be protected.

If the dura is injured, the nerves lose their protective spinal fluid cushion. After curettage King inserts screws through the facets for stability.

The Anterior Approach —Harmon contends that even the most thorough curettage of the disk space from a posterior interlaminal approach will effect removal of only a small percentage of the total intercorporeal contents. This has been demonstrated by the cadaver experiments of Falconer *et al.*

The anterior approach for removal of the contents of a degenerated lumbar disk is indicated only when the surgeon is positive of the diagnosis.

Harmon regards the anterior approach as an elective operation for any type of lower lumbar intervertebral disk protrusion, except cases in which the diagnosis is not clear or in which the operator suspects massive or complete disk fragment extrusion into the extradural space. Harmon described the technic of exposure of the lower lumbar intervertebral disks by the extraperitoneal route. He reported on the immediate postoperative course of patients who have had sub-total excision of two lower lumbar intervertebral disks performed by an anterior transabdominal extraperitoneal route.

This approach, while a more extensive surgical procedure requiring meticulous surgical manipulation, allows near-total disk excision under visual control without direct contact with nerve roots. Hemorrhage is minimal and under control. The smooth postoperative course of these patients is one of the desirable features of anterior intervertebral disk excisions.

Intercorporeal Fusion —There are strong advocates and opponents of the removal of the intervertebral disks to produce vertebral fusion. Fusion of the two adjacent vertebral bodies would appear on theoretical grounds to be the most satisfactory type of fusion. Semmes performed fusion following curettage of the cartilage plates. Cloward* presented an ingenious technic. Wittenberg advanced another procedure.

Anatomical Findings at Operation —*Protrusion* means that the disk material is confined to the intervertebral space but causes a bulge in the posterior spinal ligament.

Extrusion means that disk material has escaped from its intervertebral space and presupposes rupture of longitudinal ligament.

Disk degeneration means a soft boggy disk that has not ruptured.

Mixter demands visible demonstration of compression of the overlying nerve root, before he is convinced that a ruptured disk has caused the patient's trouble.

* The intra abdominal approach with fusion between the bodies or destruction of the epiphyseal cartilaginous plate if found *practical may* help solve some of the problems of scoliosis hemivertebra fractures and diseases of the vertebral bodies.

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"ruptured disks." They operated on 32 patients with sciatica. In 18 an adequate explanation for the sciatica was demonstrated at operation. The pathologic condition in some of these 18 cases apparently was not the actual cause of the sciatic pain. No lesion was found at operation in 3 per cent of Pennybacker's cases.

Young reports there were 12 patients with negative explorations who continued to have typical disk attacks. Of these 4 cases were severe enough to require re-exploration at which time, a disk was found. In the follow-up examination, 616 patients with proved disk protrusion and 60 with degenerated disk were studied. Severe recurrences were found in 133 patients. Of these 18 were re-explored and further protrusion was found while 2 were operated on for a second recurrence. Recurrence occurred at another level rather than at the same interspace in the proportion of two to one. Recurrence at the same disk usually followed inadequate removal, frequently due to the disk being "unripe" or not sufficiently degenerated to permit removal. Pain was unrelieved by operation in 44 cases. Re-exploration in 22 of these showed a further protrusion in 9, 6 of these being at another level. The remaining 13 had dense perineural and peridural adhesions binding the root to the mobile posterior part of the canal.

In the cases in which disk lesions without protrusion were found, the results were only about half as good as in those with protrusion.

Operative Incidents and Accidents.—A common occurrence is the sudden jumping of a thigh or leg when a lumbar spinal nerve is compressed during the operation. It is a very valuable warning or danger signal.

Operative Complications or Accidents.—The anterior longitudinal ligament is not impregnable and it is possible for an instrument to be jammed through it into the inferior vena cava or into the aorta, especially when the dissection involves the lateral areas rather than those near the mid line.

Dangers attending operation are chiefly puncturing tissues and structures such as the anterior spinal ligament, large blood vessels, the vena cava and small blood vessels.

The use of sharp cutting instruments in an intervertebral space is fraught with real danger. Love reported on one patient who had an arteriovenous fistula (aorta to inferior vena cava), following removal elsewhere of a protruded intervertebral disk. Love heard of another patient who went into a state of shock and died, following removal of a protruded intervertebral disk. When postmortem examination was made, a perforation of the abdominal aorta was discovered, with fatal hemorrhage.

Cases have been reported of rupture of the vena cava, rupture of an iliac artery, and rupture of an arterio-venous aneurysm.

THE COMBINED OPERATION—EXPLORATION AND PRIMARY FUSION

The attitudes of various authorities regarding primary fusion after exploration for ruptured disk lesions, uncomplicated by bony abnormality, are often widely divergent.

"Never say never."

"Never say "always."

LOCAL DISK SITUATIONS—MECHANICAL

Prolapse	Extrusion
Protrusion	Concealed Disk
Rupture	Intermittent Prolapse
Slipped	Degenerated
Herniated	Scarred disk
	Soft Disk
	'Unripe' Disk

1 Flat firm and apparently normal
2 Soft with thin annulus
3 Slightly bulging and firm
4 Large with dome-like protrusion
5 Extruded through annulus
6 Free in canal, or adherent

The protruded masses are usually single, but may be multiple They are usually *situated lateral to the posterior longitudinal ligament* A completely prolapsed nucleus pulposus may be found lying free within the canal It may be necessary to use a sharp knife or even a curet to remove the partially dislodged particles of nucleus pulposus

In the 913 cases with operative treatment in R H Young s series the following findings were recorded

1 Protrusion 750 cases
2 Disk lesions without protrusions, 82
3 Osteoarthritis causing root irritation 22
4 Abscess 3
5 Tumors 2
6 Peridural adhesions 12
7 Negative exploration 42
8 Multiple disk protrusions were found in 12 per cent

The disk lesions other than protrusion included (1) A bulging springy annulus with a degenerated and fragmented disk (2) a soft area in the disk (3) a scarred disk meaning a narrowed inelastic disk to which the nerve is often adherent (4) In osteoarthritis nerve root pressure was found to be due to posterolateral lipping Chiseling off this lipping relieved pain

There were 42 patients with negative explorations who continued to have typical attacks Of these 4 cases were severe enough to require re-exploration when a protruded disk was found

MacNab and Harris describe some disks as resembling putty in consistency Burns and Young uncovered abscesses in 3 cases and epiduritis or peridural adhesions in 12 cases 2 of which followed lumbar punctures

Negative Explorations for Disk Lesions and Recurrences —Explanation (1) Inadequate exploration, (2) inadequate observation or visualization (3) wrong level investigated

Echols and Rehfeld reported that no pathologic condition could be demonstrated at operation in 14 patients who had been diagnosed as having

The number of combined operations performed has increased during the years covered by a study made by Ghormley, Love and Young. The increase in this percentage is due not only to the fact that both neurosurgeon and orthopedic surgeon felt that some patients with protruded disk should undergo bone grafting but also to the fact that in many cases in which the orthopedic surgeon had planned a bone grafting operation he asked that the neurosurgeon perform a laminectomy so that it could be determined whether or not a protruded disk might be present. In the latter group they particularly refer to cases of spondylolisthesis, spondylolysis and the like.

It was their opinion that the surgeon could promise relief to the majority of patients with protruded intervertebral disks, by removal of the protrusion alone. However, it was also their opinion that there was a group of cases in which a bone graft or fusion operation should be done.

It must be borne in mind that the roentgenographic appearance alone is not the determining factor in cases in which combined operations are chosen. A careful review of the patient's history must be made and the symptoms must be analyzed. Many patients who have a long-standing static type of backache and who have evidence of a superimposed protruded disk whose pain is not relieved by rest, are improperly advised to undergo the combined operation.

In those cases where a combined operation is to be performed it should be done by two teams, if they are available: first, a neurosurgical team and, second, the orthopedic surgical team.

When a fusion is performed, the placement of the grafts is of great importance. It is imperative that the grafts be in contact with bone. Bilateral grafts, i. e., one on each side, using heavy grafts, is advisable. If the grafts are not in contact with bone, hemorrhage will float them apart and failure of consolidation is almost inevitable. It is important that a dry field be maintained because hemorrhage will jeopardize the fusion. There must be no slipping of any of the bone grafts because slipping will cause pressure on the dura and nerve pain. If the dura is opened and cerebrospinal fluid leaks out, it will "float" the grafts and jeopardize bone contact and subsequent fusion.

Ingebrigtsen's indications for primary spine fusion are spondylolisthesis, narrowing of more than one disk, and retroposition of a vertebra. The operation is indicated when an inferior articular process had been partially resected at operation.

Barr predicted that all patients operated upon for the removal of a ruptured intervertebral disk will have the spine stabilized. Caldwell's statement was equally dramatic: "There are no criteria for spine fusion following removal of a protruded nucleus pulposus." Such widely divergent views, expressed by capable men, constitute conclusive evidence of incomplete knowledge of the subject. The answer undoubtedly lies somewhere between these two extremes.

Ghormley, Love and Young reported a group of cases in which one member of the neurosurgical staff explored the spinal canal for evidence of an intraspinal lesion (and removed it if it was found) and in which one member of the orthopedic surgical staff carried out bone grafting to bridge the affected area.

We need fusion of thoughts as well as fusion of vertebrae. Five per cent of all suspected "disk cases" have a spinal cord tumor, therefore, beware of primary fusion.

All the deaths in Mixter's series were in patients who had had a combined operation.

The Mayo Clinic surgeons have gradually increased the frequency of the combined fusion procedure from 10 per cent to 40 per cent.

A second operation after primary fusion is like drilling through a mosaic floor. The required "blasting" causes harm.

Spinal fusion is usually not justified unless a primary operation has failed.

Some surgeons perform arthrodesis only if relief from pain by conservative measures is incomplete, and if the instability of the area can be reasonably assumed to be the cause of persisting symptoms.

Some surgeons consider fusion the second stage of what might be a two-stage affair.

Ghormley, Love and Young found nothing in the review of their series of cases that would lead them to advocate fusion in all cases in which protruded intervertebral disks are removed.

The opinions of the experts are often divergent with justifiable pros and cons. The question of primary spinal fusion narrows down to the personal experiences of those who have extensive material. The removal of a protruded disk, does not give the person a new back any more than removal of the hurdles from a track gives a hurdler the gold medal. Barr recommends primary fusion. There are others who say never fuse at the primary operation.

Some orthopedic surgeons have expressed the opinion that all patienst who undergo removal of a protruded intervertebral disk should also have a fusion operation at the same time. Some surgeons feel that the combined operation would give added stability to the back; others feel that recurrent protrusions would thereby be avoided.

Disk Excision and Spine Fusion.—Some authorities advise fusion in every case; others never advise it. There is no doubt that satisfactory results are obtained by (1) removal of a protruded disk, (2) removal of the fragments of a degenerated disk.

There is no doubt that these procedures may fail to relieve some patients and if the person is to return to heavy duty, a spine fusion should supplement the exploratory operation. The cases in which the combined procedure of hemilaminectomy, removal of the disk and bone grafting is indicated include such conditions as spondylolisthesis, separated neural arch without slipping of the vertebral body and marked narrowing of an intervertebral space with hypertrophic arthritic changes.

The static type of back trouble and the chronic type of back trouble may require a fusion operation. The history of the case, the physical examination, the roentgen-ray findings and the occupation determine whether a fusion should be performed. Each surgeon must decide for himself whether the combined operation should be done at one time or in two separate stages. If it is to be done in two stages the patient should be told before the first operation that a second one should be performed later.

Indications for Fusion—The indications may be "relative" or "absolute." It is hoped and expected that the combined operation will minimize the incidence of recurrence of protruded disks.

Fusion is the operation of Burns and Young's choice in the following situations: (1) spondylolisthesis, (2) adhesions following disk removal, (3) re-exploration after a fusion operation.

Grafting is unsuitable in patients with signs and symptoms of a definite protrusion because (1) if the protrusion is not removed the outlook is unfavorable, (2) removal of the protrusion is usually sufficient to afford relief.

Echols has collaborated in the combined operation, whenever it has been recommended by the orthopedist. After ten years' experience, he and his colleagues concluded that since results of operation for removal of a ruptured disk are so satisfactory in carefully selected cases, the combined operation is unnecessary, except in unusual circumstances.

Adson found that the removal of a protruded disk affords relief to patients whose symptoms arise from irritation of a nerve produced by a bulging, cartilaginous mass. However, not all the symptoms may be due to the protrusion or a prolapse of the nucleus pulposus, since there may be accompanying arthritis, beginning spondylolisthesis, sacralization of the last lumbar vertebra or the existence of a long and excessively movable lumbar segment of the spinal column. When such a situation exists, neither the removal of the protruded portion of the disk nor the insertion of a bone graft in the sacrolumbar region will suffice as a single operation. It is in this particular group that the combined operation is indicated, since the patient needs the stabilization afforded by the fusion procedure in addition to the removal of the offending bulging protruded disk.

Briggs and Milligan believe that the object of fusion is to prevent a reherniation of nuclear material, if there has been a removal of a ruptured nucleus pulposus, and to prevent a late constriction of the intervertebral foramen. The intervertebral foramen can be constricted by compression of an intervertebral space by an outward bulging of a disk, or by the development of hypertrophic bone changes. When the mobility and resiliency of a disk is lost by injury or disease, nature tends to fuse the adjacent bodies by hypertrophic lipping.

A facet is frequently destroyed or entirely removed at operation, making a fusion desirable to insure mechanical stability. Echols and Rehfeldt do not advise spinal fusion at the time a disk is removed.

At the New York Orthopædic Hospital Smith and Halloch see a considerable number of patients suffering with sciatica from herniated nuclei, who have had a long history of annoying or disabling back pain and in whom x-rays show faulty mechanics or degenerative changes at the lumbosacral joint. These patients should have, in addition to removal of the nucleus, a fusion as there are two distinct conditions and each requires treatment.

Spurling and Grantham recommend that primary fusion be reserved as a secondary procedure for those persons in whom persistence of symptoms warrants additional surgery.

It is their opinion that the surgeon can promise the majority of patients with protruded intervertebral disks, relief by removal of the protrusion alone However, there is a group of cases in which a bone graft or fusion operation should be done

In many of the large centers in the United States, including the Mayo Clinic and the Massachusetts General Hospital, the combined operation is advised in many instances, and a considerable proportion of the disk cases are treated by immediate arthrodesis

Spurling considers fusion to be contraindicated at the original operation Caldwell believes that fusion should not be considered for at least a year after exploration Fusion does not always prevent recurrence of disk symptoms

Many surgeons advise spinal fusion for all ruptured disk patients Others report just as good over all results by simple removal of the herniated fragments of the ruptured disk The high percentage of patients not cured by either of these procedures has resulted in an even more conservative attitude by some

It is Cloward's opinion that more patients will be permanently cured of their symptoms if removal of the ruptured disk is followed immediately by bony fixation of the involved vertebral joint He seriously believes that all lumbar disk operations should be accompanied by a spinal fusion and that the fusion should be done between the bodies of the vertebrae

Barr predicted universal fusion following disk exploration Holscher goes to the other extreme with the statement that before Barr's prediction comes true and as a result of improved manipulative technic and other conservative treatment, the operation for the removal of ruptured intervertebral disks will have been discarded

This is certainly a far-fetched conclusion and cannot possibly be substantiated

Some orthopedic surgeons have contended that, even if a protruded intervertebral disk were present, a fusion operation would relieve low-back pain and sciatic pain Love agrees that some lumbosacral protrusions undoubtedly have been cured by a massive bone graft applied to support the structures adjacent to the protrusion area

Magnuson feels that the spine should be permanently immobilized at the time of operation for a ruptured nucleus pulposus whether a rupture is found or not

Although the operation of disk excision for sciatic pain has been practiced in some clinics for almost twenty years and has been universally accepted as a valuable therapeutic procedure for ten years Barr finds there is as yet, no unequivocal answer to the question as to whether or not fusion should accompany disk excision

Caldwell, Spurling and others are strong advocates of simple excision Caldwell calls attention to the fact that most orthopedic surgeons who have written about the treatment of the typical disk syndrome during a ten-year period have favored removal of the protruded disk combined with spine fusion in a large proportion of cases Ghormley and associates in 1942 advised spine fusion, if sciatic pain occurred in the presence of spondylolisthesis spondylolysis, lumbosacral arthritis or a combination of these

Gareau finds that a simple disk operation is satisfactory in a large percentage of cases

Transitional vertebra instability of the spine due to insufficiency of the facets and arthritis are indications for spine fusion

Spondylolisthesis and spondylolysis are definite indications for spine fusion

Reoperation for symptoms arising from the same disk level are usually indications for fusion Reoperation for a second disk at a different level is not an indication for fusion

Barr feels that as operative technic improves the difficulties of the combined operation are minimized and will in the near future be the operation of choice for the majority of patients

Barr feels that any spinal segment from which a ruptured intervertebral disk has been removed surgically is no longer mechanically and anatomically normal

End result studies indicate that at least 50 per cent of patients who have had a ruptured disk removed without spine fusion suffer to some degree from weakness or pain in the back In some of these cases the disability is severe and may be incapacitating

If there were no movement in the fourth and fifth lumbar vertebrae there wouldn t be any extruded disks in this region Many of these patients as the years go by, begin to have recurrences of symptoms because the spaces for the nerve roots are diminished so much that they undergo arthritic changes and produce painful pressure on these nerves Ryerson advises that fusion operations should be performed in all cases of disk removal

The decision is made chiefly on the basis of

1 Previous history (Long standing back derangement)
2 X-ray visualization—congenital anomalies
3 Patient s occupation
4 Patient's economic status
5 Findings at operation (instability)

The consensus of the experts is that fusion is advised in the presence of certain congenital anomalies or spondylolisthesis In regard to uncomplicated disk syndromes there is great divergence of opinion

Most neurosurgeons are content to do no more than remove the ruptured intervertebral disks Speigel has rechecked freely lying ruptured disks on 3 occasions where the operation had been followed by surgical fusion by an expert Each of the 3 cases have had recurrences and re exploration by him revealed another freely lying disk In his experience the best results are in those persons who were *not fused* primarily

Briggs and Milligan advise primary fusion because there will be less inflammation less calcification and less constriction of the intervertebral foramen if a fusion is performed at the time of exploration

Caldwell reviewed a series of cases of ruptured intervertebral disks operated upon without spine fusion and compared the results with similar series of cases reported from other clinics His conclusion is that excellent and satisfactory results can be obtained in as high a percentage of persons treated by laminectomy alone as in those who were subjected to the combined operation

In Pouyanne's opinion, fusion is indicated for displaced vertebrae, limited arthrosis, unsatisfactory disk operations, and old and recalcitrant lumbar pain. In the heavy laborer it is considered advisable. About 10 per cent of his patients require fusion.

In those few cases that were explored for chronic backache where neither O'Connell nor Armstrong found a definite protrusion but did find degenerated disks, they performed bone grafting.

In general, the indications as outlined by Walsh and Love are followed. In many cases of congenital anomaly, such as sacralization, an anomalous neural arch or anomalous conformation or position of the body of the vertebra, in which there is instability of the vertebra in question, bone grafting *should be done*.

No qualified orthopedic surgeon will say "this patient must have a primary spinal fusion." A brace can be applied and a spinal fusion can be done at a later date.

Steindler advises fusion in all cases in which instability of the lumbosacral junction has manifested itself by prolonged and repeated attacks of backache.

Some of the arguments put forward against fusion as quoted by Jones, are: 1. Fusion requires a moderate increase in the scope of the operation.

2. Should a good result not be attained, future exploration may entail the difficulty of removing a bone graft or digging through much bone.

3. Fusion concentrates the strain above the level of the fusion.

Some of the arguments in favor of fusion are: 1. Removal of an intervertebral disk increases the instability of a joint that is already in trouble.

2. *A considerable number of painful backs that follow a neurosurgical* procedure without fusion are later relieved by fusion.

3. The use of two teams does not greatly prolong the time of operation.

4. Where only low-back fusion is done, the postoperative period of disability is not too prolonged.

Many surgeons advise spinal fusion following removal of a ruptured disk, some almost routinely, others largely in industrial cases, in which heavy work must be resumed. Where compensation is a factor, Grant feels that a fusion may not diminish the complaints.

In industrial cases the surgeon may be in a dilemma in that the person needs a fusion in order to perform hard work. The fusion requires months for consolidation. During this period the person may learn to enjoy the *enforced idleness which will prolong his compensation-disability*.

Wardle condemned primary fusion as unnecessary. He found it increased the complications and danger and required a more prolonged postoperative immobilization. Where it was necessary fusion could more conveniently be undertaken later. There is no doubt about the difficulty of a secondary operation on one or more nerve roots, after a primary fusion has been performed.

Mixter finds that the criteria for fusion or non fusion are not definite. He believes that one should consider (1) whether or not the patient must do heavy lifting, (2) the presence of abnormal mobility, (3) the presence of a structurally weak spine, (4) the predominance of back symptoms. He is guided by the orthopedic consultant.

CHAPTER 60

FUSION OPERATIONS

Fusion operations have been described by Hibbs, Albee, Delagenière, Lewin, Gibson, Bosworth, Moore, Nicoll, Anderson, Wilson and Campbell, Judet, Orell, Harmon, Young and Burns, O'Connell, Armstrong, Cloward, and Wittenberg.

In every arthrodesis the factors involved are anatomical, biological, physiological, biomechanical (physical) and biochemical.

The principles of fusion demand: 1. An accurate approximation of bones like the "fit" of a cabinetmaker.

2. Proper relationship of portions of the "parts" to each; and,

3. Firm retention in proper position until consolidation is complete and is proved clinically and roentgenologically.

Each surgeon has his own convictions regarding: 1. Long or short fusions.

2. Methods of stabilization.

3. Sources of supply of bone.

The operation must be performed so that one can see that the nerve is clear, before grafting is carried out. The usual extra materials are: wire, rods of metal or celluloid, bone, metal, acrylic screws, bolts.

The majority of Briggs' cases have been explored at the lumbosacral level and a lumbosacral fusion has been performed. When the fourth lumbar disk, or one at a higher level, has been removed, only the adjacent segments involved are fused. Fusion is carried out from the fourth lumbar vertebra, to the sacrum in fifth lumbar spondylolisthesis. In fourth lumbar disk disorders, if the fifth lumbar vertebra is definitely "unstable" at operation, a fusion is advised.

After removal of a ruptured nucleus of the fourth lumbar vertebra, the fusion is extended only from the fourth to the fifth lumbar vertebra.

Briggs advises that fusion of the adjacent segments should be performed following operation for disorders of an intervertebral disk. He recommends the chip fusion operation.

Fusion vs Stabilization.—The purpose of fusion during a remission of symptoms is to "lock the area in status quo."

The purpose of stabilization is to correct a mechanically inefficient group of vertebræ.

While the neurosurgical team proceeds with the laminectomy, the orthopedic team removes the required bone from the tibia. As a rule, bilateral grafts are placed across the unstable region, which usually consists of the area from the fourth lumbar arch to the second sacral arch. If iliac bone is to be used, the "bone team" will be delayed.

At the Mayo Clinic when a "combined operation" is performed in conjunction with an orthopedic surgeon, a tibial graft is employed. It is

The results of Caldwell's study suggest the following There are no criteria that prescribe spine fusion following removal of a protruded nucleus pulposus

1 Excellent and satisfactory results can be obtained in as high a percentage of cases by laminectomy alone as by the combined operation

2 Hypertrophic changes of variable degree with or without narrowing of the disk occurred in 69 3 per cent of the cases studied

3 Functional end results do not correspond with, or depend upon, the presence or extent of such postoperative changes

4 The end results are not significantly related to the existence of anomalies

5 The recurrences that occurred in 8 per cent of the cases studied, did not seem to be related to the presence of anomalies or postoperative narrowing of a disk or hypertrophic bone changes

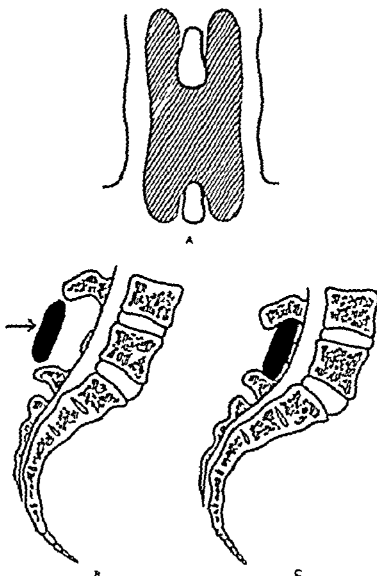


FIG 369 —The H shaped iliac graft The H shaped iliac graft lies on the posterior surface of the lamina after one spinous process has been removed (A) To 'spring' this graft into position the spine is flexed so that the transverse bar of the H just slips between the spinous processes above and below (B) The spine is then extended and the graft is 'locked' in its bed (C) (Armstrong Lumbar Disc Lesions courtesy of E & S Livingstone Ltd)

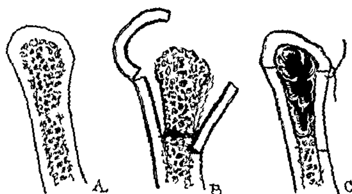


FIG 370 —*A* and *B* Method of taking iliac bone *C* Blood clot dark portion (After Robertson and Barron)

placed posteriorly, in contact with the laminæ and spinous processes of the adjacent vertebræ. Regardless of whether the protruded intervertebral disk is at the fourth or fifth lumbar interspace, orthopedic surgeons usually fuse the last two lumbar vertebræ to the first two sacral segments.

Young prefers the technic of spine fusion which includes two tibial grafts bolted to the spinous processes, using spring washers to obtain compression combined with iliac grafts on the laminæ. Union, grossly and histologically, has been demonstrated at six weeks.

Like Moore and Nicoll, Armstrong favors an H-shaped graft sprung into position with the spine in full flexion. Then when the spine is extended the graft is locked by the 4th lumbar and 1st sacral spinous processes.

Some surgeons prefer iliac bone, others favor tibial or banked bone. Cloward uses banked iliac bone.

Many types of arthrodesis will result in a reasonably high proportion of satisfactory fusion. Among the methods most commonly employed are:

1. The Hibbs.
2. The Hibbs with the addition of an osteoperiosteal graft from the tibia, (Lewin).
3. A massive tibial graft, fixed to spinous processes by wiring.
4. An interbody (intercorporeal) fusion.
5. The "fish tail" technic as originally described by Gibson and subsequently modified as the "clothespin" method, by Bosworth.
6. Chip graft fusion—(Henry-Briggs).
7. Cloward's banked iliac bone for intercorporeal fusion.
8. Anterior intercorporeal fusion.

Atkin's patients who had a spinal fusion as well as removal of the ruptured disk at surgery had better postoperative results. Spinal fusion, when it was a secondary operation gave much poorer results than when performed at the initial operation. The placing of a bone graft for fusion purposes does not, in all cases, prevent recurrence of disk protrusion beneath the graft.

Love has observed recurrent symptoms from a protruded intervertebral disk at the third lumbar interspace after fusion of the fourth and fifth lumbar vertebræ to the sacrum combined with removal of a typical protrusion in the low lumbar area.

Wahren performed spinal fusion of the lower lumbar vertebral column in 71 cases. His best results were obtained in those cases in which the disk degeneration was localized to the lowest intervertebral disks. He believed that the success of the operation was due to fusion of the lumbosacral joint.

Unfortunately it is not always possible to insure solid fusion of the last two lumbar vertebræ to the sacrum. An unstable spine is one of the most common causes of unsatisfactory results in both operated cases and those treated by conservative means. Orthopedic surgeons recognize an "*unstable fifth lumbar vertebra*" as a definite entity.

Some orthopedic surgeons have contended that even if a protruded intervertebral disk were present a fusion operation would relieve low back pain and sciatic pain. Some lumbosacral protrusions—possibly even some at the fourth lumbar interspace—undoubtedly have been cured by a massive bone graft, applied to support the interspace at which the protrusion had

Two statistical studies of the comparative results of disk excision and excision fusion have been reported by Barr. In both of them the combined operation appeared to be somewhat superior.

Recently, a third series of cases has been studied by Barr and has been reported. His tables are worthy of study.

Armstrong believes that a successful fusion of a damaged joint carried out in association with complete removal of the degenerated nucleus appears to be the ideal surgical treatment for a lumbar disk.

Some Important Notes on Bone Grafting for Spine Fixation. In lumbosacral fusion, one needs a lot of bone plus secure fixation.

A firm stabilization is accomplished by two tibial grafts and screws to spinous processes plus iliac grafts to laminae. Compression is desirable.

A screw may hold the bone surfaces apart, a bolt holds them together.

After the use of a spring washer and bolt, union has been demonstrated at six weeks but one should not count on it.

Nachlas asks: What component of the operation produces the relief? He speculates regarding whether a disk operation does not carry with it some of the elements of such procedures as sacro-iliac manipulation, exposure and stretching of the sciatic nerve, fasciotomies and myotomies.

As the reader progresses with this section, he will be impressed with the fact that at times one may ask the question:

Is It Fusion or Confusion, or Is It Fusion of Vertebræ
vs
Confusion of Thoughts?

We need to dispel the confusion and substitute "Diffusion" of information.

I cannot subscribe to the position of some surgeons who advise "*Always fuse.*" Their contention is that a degenerated disk means a degenerated spinal canal or column. In some cases, it is like sealing an object under the mosaic floor of your bathroom. I also cannot accept the stand of other surgeons who advise "*Never fuse.*"

Admonition.—Never do a fusion unless you have found enough unmistakable evidence pathologically to account for all the patient's symptoms and even though you have, it might not be necessary to fuse.

An appeal is made to the Hibbs group and Hibbs' disciples.

The "fusionists" of the past forty years should review their cases of fusions in cases (many of which in retrospect should have been diagnosed protruded disks) without exploration for disks.

I would like to have the "fusionists" tell us about how many "disk cases" they have fused without primary exploration and what the results were.

I would like to see a dispassionate analysis and report in candid retrospect from each of the following: Albee, Hibbs, Ryerson, Smith, Chandler and others.

In 1943, because of frequent recurrence of symptoms of patients operated upon for ruptured intervertebral disk, Cloward began experimenting with a different type of operation. The purpose of the procedure was to im-

occurred This is not inconsistent with Love's conception of the pathological appearance and pathogenesis of protruded intervertebral disks, for the protruded fragment of disk is often very edematous, and the compressed nerve root usually is enlarged and edematous at the time of operation for the removal of a protruded disk Likewise, the extradural vessels about the nerve root usually are congested at the time of operation If the interspace is sufficiently splinted and the patient remains in the hospital for a sufficient time after application of the bone graft, the edema of the protruded cartilage and the nerve root, and the congestion of the extradural vessels may subside sufficiently to relieve the compression of the nerve root Some patients have required operative intervention, however, with removal of a protruded disk from beneath the bone graft which had previously been applied

The results of laminectomy without fusion have been reported by Lenhard, Love, Barr, and others, and, although they indicate that the back and sciatic pain is relieved in 53 to 67 per cent of the cases, many were not completely relieved and still complained of some degree of pain in the back It has been assumed, therefore, that the pathological changes in the disk progressed after operation, because of instability of the joint, and that these changes could have been prevented by supplementing removal of the protruded nucleus with fusion of the involved segments of the spine Comparison of groups of cases with and without spine fusion, indicates a higher percentage of good results from the combined procedure, based on follow-up examinations or answers to questionnaires sent to the patients However, reports from an insurance company by Marble and Bishop indicate that the combined operation gave good results in only 14 to 40 per cent of cases

Steindler's results were better in the group of patients who had exploration and primary fusion operation

Barr and Mixter found that with laminectomy and disk removal alone, the relief of back symptoms was not so satisfactory as was the relief of the radiation pain Seventy-three per cent of the patients in whom the spine had been fused had relief of the back symptoms and only 52 per cent of the patients without fusion, had no further back symptoms

Ghormley, Love and Young reporting on 77 patients with protruded disks who had the combined operation of laminectomy and fusion, found the results good in 64 per cent fair in 25 per cent and poor in 11 per cent

Caldwell and Sheppard conclude "There are no criteria for spine fusion following removal of a protruded nucleus pulposus"

At the Mayo Clinic, Young and Walsh report that their figures indicate that the results of the combined operation are somewhat better than the results of disk excision only

Garceau reporting the comparative results in 50 cases with the combined operation and 50 cases with excision only, noted no statistical difference in the end results

At the Massachusetts General Hospital the combined operation of disk excision and spine fusion has been performed on selected cases About 30 to 40 per cent of their disk cases have had the combined operation Their staff has been aware of the potential benefits to be derived from this operation, but have also recognized its technical difficulties

Cloward found that in an operation for fixation of the spine following loss of an intervertebral disk the use of cadaver bone has proved to be both safe and effective. The dangers of infection have been eliminated by preserving the bone in a known sterile solution. The operation which took three and a half to four hours or longer to perform has been reduced to two hours or less. The patient's hospital stay has been shortened to a week or ten days because there is but one wound to heal and the availability of more bone makes a stronger fusion.

ANTERIOR HERNIATION OF A RUPTURED LUMBAR INTERVERTEBRAL DISK

Cloward's finding of an anterior herniation of a ruptured intervertebral disk diagnosed preoperatively by *x*-ray study and verified at operation may throw some light on the failure of many patients to be cured of low-back pain after the standard disk operation. The disk operation as performed by Cloward offers a wider exposure for a more thorough investigation of the intervertebral space under direct vision. The finding of a loose piece, or pieces of torn intervertebral disk lying within the interspace and at times lying far anterior, indicates the necessity of a more complete visualization of the disk. If the patient's back pain is to be cured and/or a recurrence of his sciatica prevented, a complete removal of these fragments is essential.

Cloward described a case in which a large fragment of torn disk was demonstrated preoperatively by *x*-ray study and verified at surgery to have herniated far anterior in the intervertebral space. In a standard disk operation this loose piece of intervertebral disk would most likely have been missed.

The value of the diagnostic procedure using a diskogram in recognizing the presence of a ruptured disk in the absence of objective physical findings is emphasized by Cloward.

A permanent cure of disability due to a ruptured disk may be assured by fusing the vertebral bodies after complete removal of the intervertebral disk.

ASSOCIATION OF SPONDYLOLISTHESIS AND SCIATIC PAIN AND THE DISK SYNDROME

Meyerding was impressed by the number of cases in which spondylolisthesis was associated with sciatic pain and protrusion of an intervertebral disk. Protrusion was diagnosed in 15 of 25 cases in which spondylolisthesis was associated with sciatica. The diagnosis was confirmed in 6 cases. The treatment which offers the greatest benefit with the shortest period of disability and the longest period of relief is surgical removal of the protruded disk and fusion of the last three lumbar vertebrae with the sacrum.

The information learned and the observations on Dandy's series of surgical patients has led to the conclusions that (1) the spondylolisthesis is usually responsible for only part, and at times, none of the symptoms, (2) in most instances it is not the spondylolisthesis or even the disk at its

mobilize the loose vertebral joint by effecting a bony fusion of the vertebral bodies

The operation consists of a subtotal removal of a lumbar disk, including the cortical surfaces of the adjacent vertebral bodies, and the driving of three or more full-thickness bone grafts, removed from an iliac crest, into the intervertebral space This is done through a partial bilateral laminectomy

As a culmination of these experiments over a period of years, a self retaining vertebra retractor has been developed which is small, practical, and easy to use *This will be appreciated by the orthopedic surgeon who* contemplates a posterior type of spinal fusion For those who wish to do the anterior (vertebral body) fusion, which in Cloward's experience has given results far superior to any operative procedure yet reported for ruptured intervertebral disk, *the instrument is indispensable* This instrument when used with the self-retaining dura retractor has made the surgical procedure for lesions anterior to the spinal dura mater safe and relatively simple It has likewise made an operation for bony fusion of the vertebral bodies almost as easy and not much more time consuming in the hands of an experienced neurosurgeon, than a "simple" disk removal

The orthopedic surgeon will find the vertebra retractor especially useful for posterior spinal fusions In performing the Hibb's spinal fusion with the vertebra retractor the articular facets can be spread and held so wide apart that the cartilage removal, chiseling and packing process can be done without removing part of the facet This assures a heavier bony support at the facet, and is conducive to a more rapid and stronger fusion

In the fusion operation of inserting an "H" or "clothes-pin" graft between the spinous processes, this instrument is especially helpful By placing the spreader between the laminae, a wide separation of the spinous processes can be obtained and held until the graft is inserted

The hazard of such an operation has been removed by the development of an instrument which Cloward calls a self-retaining spinal dura retractor

This leaves the surgeon with both hands free to do the operation The danger of injury to the nerve root, and/or the spinal cord which may occur from the constant pulling and mauling of these important structures with a hand retractor is minimized if not eliminated

Cloward presents a detailed description of his operative technic for fusion of the vertebral bodies after removal of a ruptured lumbar intervertebral disk

His experience with this operation in a series of 321 cases followed over a period of eight years was very favorable The rapidity with which patients recover from this operation and the high percentage of complete long-term cures (over 85 per cent) justify to him the conclusion that this operation is the treatment of choice in the care of a patient with a ruptured lumbar intervertebral disk

Cloward described his technic of an original operation for the treatment of ruptured intervertebral disks This consisted of fusion of the bodies of the vertebræ The intervertebral disk was completely removed through a partial bilateral laminectomy and replaced by full thickness bone grafts obtained from the crest of an ilium He has performed this procedure on 262 patients since 1943

One must distinguish pain due to surgery from pain due to the failure of surgery.

Stormy Convalescences, Post operative Pain. — A stormy convalescence may suddenly interrupt several uneventful postoperative days.

The chief causes are { Previous condition; Surgical irritation; Hemorrhage; Adhesions }

Retained pantopaque after myelography may cause trouble. The common locations of pain are the back and legs. There may be pain at the operative site or at other locations.

For those persons who have a stormy few days following adequate surgical procedure, I have found a very effective regimen:

1. Tolserol intravenously every other day
2. Butazolidin
3. Caudal epidural injection of novocaine
4. Plaster of Paris cast
5. Traction

In cases of "Meningismus" that may be related to leakage of cerebrospinal fluid, I prescribe a low lying head posture plus salicylates.

If catheterization is necessary, it is an unfavorable sign. If catheterization must be repeated, one should call in an urologist to assume full charge of that complication.

Postoperative genito-urinary complications are guarded against by a preoperative genito-urinary survey.

Of the patients who were operated on, there are more than 500 whom Milliken has followed for more than five years. More than 100 patients were used as controls; they had sciatica attributable to protruded intervertebral disks of about the same severity as the operated group, but they did not wish to undergo operation. In the list of figures compiled for this group two are statistically significant: (1) "former job 100 per cent capacity"—half of the surgical patients were able to carry on and only 30 per cent of the nonsurgical patients; (2) recurrence of definite attacks of sciatica—5 per cent for the surgical group, 60 per cent for the nonsurgical group—a highly significant figure as far as results are concerned.

Love would like to be able to report a higher percentage of complete relief five years after removal of a protruded intervertebral disk. Better results are anticipated in the future. There will always be some patients, however, who fail to obtain complete relief. Shinners and Hamby noted that 59.6 per cent of surgically treated patients considered themselves well as against only 29.5 per cent of those treated conservatively. Lewey reported that less than 33 per cent of patients with a "bulging" disk experienced benefit from surgical treatment.

One surgeon admitted failure to relieve back pain in 83 per cent of spinal fusion operations, the failure being due to pseudoarthrosis. A review of fusion operation performed at all levels of the spine showed the greatest number of failures to occur at the interspace below L4.

site that causes the symptoms but rather another disk or disks and (3) therefore the cure depends more on removal of the other disk or disks than on the one at the site of spondylolisthesis

There is a tendency toward the interpretation of the signs and symptoms of the combination and disk lesions to be due to the disk disorder rather than the spondylolisthesis

There is a sort of experiment existent, *viz* —removal of the offending disk only Many neurosurgeons are especially pleased with this procedure However, time and only time will prove the point

AFTER A DISK OPERATION

After operation there are two types of reports to the patient and family

1 *No pathologic process could be demonstrated at operation It was not wise to explore further*

2 "Madam I have found enough to account for all your husband s back and leg trouble and I have removed it completely Your husband should be perfectly well, but time and time alone, will tell"

Postoperative care includes bed rest for two or three weeks, a brace for four to six weeks, and a convalescent period of at least three months Some surgeons prescribe a split mattress, Herzmark frame, or a Stryker frame Others use no special apparatus but place the patient on his side on a firm mattress Patients are kept in bed for eight days They are then allowed up and instructed to gradually start bending the back in all directions until full or almost full range of motion has been returned

The nursing care of the uncomplicated case is very simple Convalescence is generally satisfactory, and at discharge, before or on the eighth postoperative day most patients are able to walk The duration of hospitalization for simple laminectomy and disk removal, without fusion, is about two weeks

Spurling prescribes physical therapy on the fifth day with muscle setting exercises He gives a soldier a two weeks' furlough and a light duty job in three months and a heavy duty job in six months

Mixter considers the after-care of great importance Too often the patient is carried through the immediate postoperative phase and then dismissed to the family physician without proper instruction concerning his future activities Each patient should be told postoperatively that his spine is not as strong as before it was damaged, whether a fusion has been done or not He should be cautioned against lifting heavy weights even after recovery is complete He should be taught how to lift properly by bending his knees and lifting with his thigh muscles His back muscles are atrophic and tight Setting exercises should be started as soon as safe, and later, depending on the individual patient and the type of operation performed, limbering exercises should be added Swimming is an ideal exercise to strengthen the back muscles Some patients continue to be perfectly well years after operation as long as they continue their exercises

Complications —In a period of ten years Harmon observed 9 cases of permanent paraplegia which followed 'disk operations' (performed elsewhere)

The operative treatment of a ruptured intervertebral disk is a satisfactory procedure when the patient is properly selected and the operation is performed by a capable surgeon

The results in compensation cases are sufficiently good to warrant surgical treatment of patients with intractable low back and sciatic pain

Spurling and Grantham reported on a follow up study of 378 patients submitted to simple removal operation for ruptured lumbar intervertebral disk Forty per cent were cured, 39 per cent were satisfactory 21 per cent were fair or failures, 85 per cent returned to their previous occupations, 2 2 per cent couldn t work at all

The adjustment to the change in the situation brought about by the operation is not always rapid or easily accomplished

Sixty per cent of Grant's patients were regarded as cured Eighty-seven per cent were fully satisfied with the operation

Verbrugghen reports 83 per cent success in 75 cases Love reports 90 4 per cent improvement or 9 6 per cent poor results in 987 cases Shinners and Hamby found 50 per cent cured, 50 per cent with residual symptoms in the back or legs or both Grant reports 92 per cent improved 8 per cent unimproved Mixter had 8 7 per cent failure in 184 cases Poppen had 5 per cent poor results in 400 cases Marble and Bishop in reporting cases from an industrial standpoint found less than 50 per cent favorable results in 92 cases Adson found 90 per cent satisfactory results in those who received no compensation and 77 per cent satisfactory in those who did receive compensation In a series of cases of Key and associates 82 3 per cent received no compensation 18 7 per cent received compensation during their illness for an average of four months The shortest compensation period was seven weeks, the longest two years Sixteen and three tenths per cent of the 43 receiving compensation were failures Other published results show from 23 to over 50 per cent failures

Fifty per cent of the 204 returning to work did so within the first three months Falconer and his collaborators found that patients with sedentary occupations returned to work on an average of three months earlier than those engaged in manual labor

Most writers have found some residual pain in postoperative disk patients Many have intermittent residual pain which results from overwork, fatigue etc Falconer McGeorge and Begg reviewed their series of cases with predominant sciatica and those with predominant low-back pain In the sciatica group 41 per cent had no symptoms 48 per cent had intermittent pain only, and 11 per cent had continuous pain In the low-back group 45 per cent had no symptoms 40 per cent had intermittent pain only and 15 per cent had continuous pain Key had 42 7 per cent with no pain 43 0 per cent with intermittent residual pain, 11 3 per cent with intermittent residual pain 11 3 per cent with continuous pain, and 3 0 per cent not reporting Of those 99 who had intermittent residual pain, 8 had sciatica alone, 25 had low back pain alone and 64 had both sciatica and low-back pain

De Marchi reported follow-up studies on 207 patients operated on for prolapsed disks by hemilaminectomy and thorough disk removal without fusion Results were excellent in 59 per cent good in 26 per cent, poor in

The over-all results in 262 patients upon whom Cloward has performed a vertebral body fusion have shown a complete cure in 85 per cent of the patients, with restoration of the function of the spine as well as the pathologic changes to normal It might be implied from these findings that the operation of vertebral body fusion after removal of an intervertebral disk may be the answer both anatomically and physiologically to the controversial subject of the treatment of a ruptured lumbar intervertebral disk.

Persistence of symptoms led to reoperation in 33 per cent of Aitken's non-disk and in 21 per cent of disk patients Poor results were due to failure in diagnosis, to improper selection of patients for surgery and to faulty surgical technic In 35 of 200 other patients operated on by neurosurgeons or orthopedists, no disk disorder was found Of the 165 with pathology, results were excellent in 25 per cent, good in 20 per cent, fair in 21 per cent poor in 27 per cent and bad in 6 per cent After operation, 33 per cent of his disk patients and 47 per cent of non-disk patients did not return to work Women had poorer results than the men

Regardless of whether treatment is operative or conservative, it cannot restore to absolute normal, a lumbar intervertebral joint in cases where degenerative disk changes have taken place

Cloward predicts a re-evaluation in the criteria and methods of treatment of these lesions based on new information as well as an improvement in the end results of surgical treatment Excellent results were obtained by Butterworth in 22 5 per cent, good in 34 per cent, satisfactory in 41 per cent and poor in 3 5 per cent Results were better in the group that had fusions

One cause for poor results of operation for ruptured intervertebral disks is failure to recognize and remove all torn loose fragments of the ruptured disk from the intervertebral space Permanent cure of disability is assured by Arkin, by fusing the vertebral bodies after complete removal of the disk

If industrial accident cases were reviewed and examined by a panel consisting of a neurologist orthopedist and psychiatrist before surgery, Baro believes the surgeon performing laminectomies on intervertebral disk syndrome patients would have nearly 100 per cent excellent results

It is difficult to compare several series of cases from different clinics, and particularly misleading when the same criteria are not used Holscher asked a medical director of the State Compensation Insurance Fund in California to review 200 cases in which disk operations had been performed He reported 29 per cent, excellent results 23 per cent good results, 36 per cent fair results, and 12 per cent poor results

Badgley found that the ratio of operative cases to those cured or sufficiently improved to return to their work was relatively poor, from the insurance companies point of view An average failure of 18 per cent or more of persons were not relieved Sixty-five per cent were cured and about 82 per cent were pleased with the results of operation

Approximately 85 per cent of Badgley s patients felt that their disk operations were worthwhile

Some of Key s best results have been in patients whom he operated upon and in whom he did not find a disk and in whom he did nothing but explore and close the wound Conversely, some of his poorest results have been those upon whom he operated, found little or no abnormality, but took a disk out

There was thus considerable difference between the two groups in regard to complete freedom from back symptoms — 58 per cent as compared with 22 per cent. The results of fusion were satisfactory in 80 per cent of cases as compared with 64 per cent in the excision group. Of the 27 cases known to have solid fusion, 74 per cent had no symptoms and 22 per cent had only mild symptoms.

If surgical excision of protruded disk tissue is reserved for those who have a disk lesion and also have severe intractable sciatic pain, Barr anticipates gratifying results. The severe sciatic pain will be relieved in over 90 per cent of the cases. In 5 to 10 per cent the result will be classed as unsatisfactory and further surgery will be necessary for recurrent or unrelieved sciatic symptoms.

The result of disk excision, so far as back pain is concerned, is much less satisfactory. At least 50 per cent of patients complain of backache or weakness of the back.

Disk Degeneration and Instability of the Spine. — During the past thirty years certain orthopedic surgeons have recognized that lumbar backache is often due to strain or mechanical instability and in selected cases have stabilized the spine by a fusion operation. Barr believes that some of these patients had an unrecognized, unremoved disk protrusion and the operation failed to give relief. Nevertheless, spine fusion for the relief of "mechanical low back pain" is a therapeutic method of proved value. Friberg, Hirsch, and others have made valuable contributions to medical knowledge of the role of disk degeneration in the production of low back pain. Disk degeneration occurs frequently, apparently it is an example of the normal aging process in collagen bearing tissues. Loss of elasticity of a disk may be accompanied by disk space narrowing, local vertebral hypertrophic change, subluxation of articular facets, retroposition of the superior vertebra, and abnormal mobility as demonstrated in bending films. Barr feels that although in many cases disk degeneration is asymptomatic, in others it plays an undoubted role in the production of back pain. In such cases spine fusion of the involved vertebral segments is often successful in alleviating symptoms. In general a fused joint is a painless joint.

All records of the Massachusetts General Hospital of patients operated upon for an intervertebral disk lesion of the lumbar spine between January 1941 and January 1946 were reviewed in Barr's report. This group included 495 cases, of which 166 (33 per cent) had the combined excision-fusion operation and 329 (67 per cent) had excision only.

There were three deaths, all in the excision fusion group, attributed to the operative procedure. This is an operative mortality rate of 0.6 per cent.

End result Study. — The end result study was limited to cases in which:

(*a*) The original operation was performed between January 1, 1941, and January 1, 1946.

(*b*) The operative note described an unequivocal protruded lumbar disk lesion with evidence of pressure on one or more nerve roots.

(*c*) At the time of operation the patient's age was between sixteen and forty five inclusive.

Excluding those known to have died since operation, there were 346 patients to whom letters were sent, asking them to report for interview

8 5 per cent, and had in 6 per cent In 5 patients second operations were performed and in each a recurrence or a new protrusion was found

Pais reported that during the last ten years 1000 patients had been operated on for low-back and sciatic pain at the Rizzoli Institute Disk protrusions were found in 906 cases In the 94 cases where no disk protrusion was found, further exploration revealed adhesive arachnoiditis, hypertrophy of the ligamentum flavum, spondylolisthesis, spondylolysis, spina bifida, osteophytes, tuberculous arthritis and intradural tumors In some cases no pathological condition was found

The late results showed (1) 83 33 per cent were relieved, (2) 12 45 per cent were improved, (3) 1 25 per cent were unchanged, (4) 0 22 per cent were aggravated (5) in 2 75 per cent, a second operation was required because of recurrence of symptoms

Wiberg and Stahl reported the results of surgical treatment of 624 patients for prolapse of a lumbar intervertebral disk Of these, 27 (4 3 per cent) had further surgery because of persistence or recurrence of lumbosacral pain In this latter group, the operative findings were

1 Disk prolapse in the explored space, 6
2 Disk prolapse in an unexplored space, 2
3 True recurrence with further prolapse of the nucleus, 9
4 A new prolapse at another space, 5
5 Stricture of the nerve root by scar, 3
6 Diffuse disk protrusion, 1

Ingebrigtsen reported his results in 180 patients operated on for rupture of an intervertebral disk Of these, 100 were examined one or more years after the operation with the following results (1) 39 were cured, (2) 21 greatly improved, (3) 29 improved, (4) 11 were failures

In 21 of these, fusion was combined with disk excision Of the fused cases 16 patients were completely relieved, 3 were working with slight back pain, 2 were unable to work

Excellent appraisals of results have been reported by Young, Armstrong Love Spurling Burns and O'Connell

One of the finest dissertations on end results was presented by Barr * His analysis was logical accurate, unbiased and self critical An end result study of 100 cases operated on at the Massachusetts General Hospital during the period 1941 to 1946 was reported

At operation every patient was proved to have had a ruptured intervertebral disk Of these 50 were treated by disk excision alone and 50 by fusion after excision, in a combined procedure The two groups were comparable as to age sex and location of lesions

Of the cases with excision 56 per cent had no sciatic symptoms and in 42 per cent these symptoms were mild In the group with excision and fusion 68 per cent had no symptoms and 28 per cent had mild sciatic symptoms

Back symptoms were found as follows In the cases with excision none in 22 per cent and mild symptoms in 42 per cent, in the cases with excision and fusion, none in 58 per cent and mild in 22 per cent

* Dr Barr s paper was published in *The Journal of Bone & Joint Surg* (Vol *33 A* No 3 633-649 July 1951)

Relief of Back Pain.—At the end result examination 58 per cent of the patients with fusion and 22 per cent of the patients without fusion, denied having any back symptoms. Adding the patients with minor complaints to those with no symptoms Barr finds that 80 per cent of the patients with fusion and 64 per cent of the patients without fusion were essentially free of back symptoms (Table 8).

Additional Operations (Table 9).—Two of Barr's patients in the fusion group had been re-explored for a recurrent disk lesion. There were 4 re-explorations in the excision group.

Five patients who had had excision only, with disabling back symptoms had undergone re-operation (fusion) for the relief of their symptoms; the operation successfully relieved their disability in 4 of the 5 cases. Several additional patients in the excision series were considering having a fusion operation; others, although partially disabled, were unwilling to undergo further surgical measures.

TABLE 9.—ANALYSIS OF ACCUMULATIVE RECURRENCE RATES ACCORDING TO AGE GROUPS IN CASES OF PROTRUDED INTERVERTEBRAL DISK (BARR)

Time Since First Operation (Years)	*Accumulative Recurrence Rates Expressed in Percentages According to Age* 20 to 29 Years	30 to 39 Years	40 to 49 Years	50 to 59 Years
1	0	0	0	0
2	1.3	0	0	0
3	2.0	0.3	0	0
4	3.6	1.8	1.2	0.9
5	8.2	6.1	4.1	4.[illegible]

Five of the patients who had had excision plus fusion, had undergone operations for repair of pseudarthrosis with an excellent result in 1, a good result in 2 and a poor result in 2. Pseudarthrosis was present in over 20 per cent of the cases in which fusion was attempted. There were instances of completely satisfactory clinical results in the presence of a known pseudarthrosis, and conversely, there were clinical failures when the fusion area was demonstrably solid.

The aim of operative treatment is to restore as many patients as possible to normal life. An attempt was made to evaluate the result of the original operation in terms of success or failure in relieving sciatic symptoms and restoring normal back function. All cases requiring additional surgery (exploration, fusion *et cetera*) after the original operation were classified as failures. Using these criteria it was found that 74 per cent of the combined operation cases were successful as compared with 52 per cent of the excision cases.

Barr finds the relatively simple excision operation relieves disk symptoms in 90 per cent or more of the cases and those few who require re-exploration often have a second disk lesion. Most of the patients have been returned to their original occupation and the result may be classified as good or excellent in 60 per cent or more of properly performed disk excisions. An occasional poor result may be due to mechanical instability of the spine,

and examination to determine the result of treatment. Approximately 40 per cent of the patients have reported and have been examined by a physician who is not a member of the hospital staff. Fifty consecutive records of patients who had simple disk excision were compared with a similar number having the combined operation of excision-fusion. There were more males in the group who had the fusion operation than in the group who had only excision, otherwise the two series were similar. As the average time since operation was over eight years and the minimum time was five years, this may be considered a long-term follow-up report.

Selection of Cases.—Many surgeons of the Neurosurgical and Orthopædic Services, participated in the management of these cases. A few of those who had the excision plus fusion were operated upon by a member of the Orthopædic Service alone, but most of these patients had a "two-team operation," the disk excision being done by a neurosurgeon and the fusion by an orthopedic surgeon.

TABLE 8.—ANALYSIS OF ACCUMULATIVE RECURRENCE RATES ACCORDING TO SEX IN CASES OF PROTRUDED INTERVERTEBRAL DISK (BARR)

Time Since First Operation (Years)	*Accumulative Recurrence Rates**		
	Total Series (Per Cent)	*Males (Per Cent)*	*Females (Per Cent)*
1	0	0	0
2	0.2	0.2	0.3
3	0.5	0.6	0.3
4	1.9	2.1	1.6
5	5.2	5.8	3.8

The results in the excision group were not influenced by variations in operative technic. A variety of technics has been used for fusion. In general an osseous bed was prepared by some modification of the Hibbs' technic and supplementary bone was used in the form of iliac or tibial grafts. The patients with excision plus fusion averaged forty days hospital stay following operation, the patients with excision only averaged eighteen days in the hospital after operation.

Complications.—There was little difference in the two series of cases in this regard. Wound infection or phlebothrombosis occurred in 5 patients in each series.

Return to Work.—In general the patients who had had fusion were permitted to do heavy work six months after operation, while in the non fusion cases, full activity was resumed somewhat earlier, either on medical advice or of the patient's own volition.

Relief of Sciatic Pain.—Barr's study confirms numerous previously reported observations on the efficacy of disk excision for the relief of severe intractable sciatic pain. End-results showed that 97 per cent of the patients were satisfactorily relieved of their sciatic pain. Paresthesias and muscle cramps were noted by some of the patients but only 3 per cent had symptoms of any severity referable to the lower extremity. *There was no* significant difference between the fused and unfused cases.

simple removal of protruded disks, 38.5 per cent had pain in the back, and 34.5 per cent had pain in the leg.

The patients were asked if they were able to do the same work they had done before the disk protruded. Of those who had undergone simple removal of a protruded disk, 64.4 per cent answered "yes." When the patients were asked, "Do you think the removal of the protruded disk was worth while?", 93.0 per cent answered "yes."

In the group of cases studied, 47 patients had recurrent protruded disks; 45 of these patients had undergone the original operation at the Mayo Clinic and 2 had been operated upon elsewhere. Accumulative recurrence rates, percentages, and analyses according to sex and age were recorded. Of the 47 patients who had recurrent protruded disks, 24, or 51 per cent, also underwent the fusion procedure at the second operation, when the protruded disk was removed. Sixteen of these patients subsequently were operated upon elsewhere. The reports on these cases indicate that the discomfort was not relieved and that the patients were willing to undergo additional surgical procedures with the hope of obtaining relief.

In the follow-up of 738 patients Busch found that after partial hemilaminectomy, laminectomy or transligamentary operation, good results were obtained in 70 per cent, improvement in 18 per cent and unsatisfactory results in 10 per cent. The latter results were mainly due to cicatricial root compression, radiculitis, instability of the affected lumbar disk and neurosis.

The recent improvements in Cloward's surgical treatment of low-back pain due to ruptured lumbar intervertebral disk have resulted in a more rapid and complete recovery rate than he had previously been able to obtain. The excellent results observed to date in the 41 patients operated upon during 1951 can be attributed to several factors. Probably the most important is the Bone Bank. Preserved bone was used in 8 of the 43 patients operated upon during 1948, whereas 38 of the 41 patients in 1951 were fused with banked bone. A more accurate preoperative diagnosis was possible in the latter group because of the diskogram. The new instruments devised for the operation of vertebral body fusion have benefitted the surgeon by increasing the ease and speed of the surgery. They have helped the patient by eliminating the dangers of injury to the nervous system, reducing post-operative pain and other complications. This has reduced the period of disability following the surgery and has lessened considerably the expense of the illness both in time off from work and the cost of hospitalization.

FAILURES

There Will Always be Some Failures.—In a situation attended by so many variables and imponderables it is not surprising that some operations are not successful in relieving certain persons of all their complaints. There will be failures of diagnosis, localization, judgment, discovery of a lesion, and technic.

If a patient with a much diminished disk space on *x*-ray and with a history of disk trouble, or with long-standing chronic pain, suffers a new acute attack, it is due to a fresh protrusion of another disk. The old disk is extinct and is incapable of causing a severe attack of sciatica or back pain.

but it is impossible to recognize preoperatively or at the operating table the indications for fusion. It is, therefore, wiser to subject a few patients to a fusion operation at a later date than to subject many patients to a needlessly complicated original operation, with its attendant risks and prolonged after-care.

Those who favor the combined excision-fusion operation argue that a protruded disk, traumatic or degenerative, means loss of its normal elasticity, narrowing of the disk space, and articular facet changes, and that the involved segment can never be restored to anatomical or functional integrity. It is, therefore, better to stabilize it by fusion than to take the risk of an unsatisfactory result due to pain and limitation of physical activity.

Although statistical proof of the superiority of the combined fusion-excision operation is not yet available, Barr finds there is strong evidence to support this view. There is some additional operative risk in adding fusion to disk excision, and it should be omitted in cases with cardiac or other complications. A patient about to undergo disk excision should be told that his sciatic pain will almost certainly be relieved, but that he may suffer from chronic or recurrent back symptoms. He and the surgeon may then choose the relatively simple operation of excision, knowing that a later fusion may be necessary, or they may elect to undertake the combined operation of excision and fusion.

There is an obvious need for better technics of fusion; the incidence of pseudarthrosis is much too high. However, although the difficulties and problems of the combined operation are fully recognized, it seems to give final results superior to simple excision.

FOLLOW-UP STUDY OF PATIENTS OPERATED UPON FOR PROTRUDED INTERVERTEBRAL DISKS

In a paper based largely on Love's experience and opinion, an analytical report is predicated on a study of the records of 1,217 patients, operated upon because of protruded intervertebral disks by all the surgeons in the Section on Neurological Surgery of the Mayo Clinic during 1939, 1940, and 1941. Those patients who underwent a "combined operation" were operated upon by a neurosurgeon and one of the members of the Section on Orthopedics. With four or more neurosurgeons operating, there were variations in the technic as to myelography, operative removal of the protruded disk, and postoperative care of the patient.

Of the 1,217 patients operated upon for protruded intervertebral disks during the years 1939 to 1941 inclusive, 3 died in the hospital—a fatality rate of 0.25 per cent. Among these patients 854, or 70 per cent, were males, and 363, or 30 per cent, were females. One hundred and forty-eight patients had undergone a "combined operation" originally; this group constituted 12.2 per cent of the total series. Of the 1,217 patients, 987, or 81 per cent, were traced either by questionnaire or by personal interview. The percentage of those benefitted was 90.4, whereas 9.6 per cent said they had obtained no benefit from the operation. Of those who had undergone

11. Post-operative infection
12. Gross damage to the spinal theca, to the cauda equina or to the extrathecal nerve roots

Failure in cases with positive diagnostic criteria, usually results from inability to find or remove all the protruding disk material or from recurrence of the disk protrusion

Armstrong detailed the causes of operative failure as follows

1. Sometimes there was no lesion, or more often,
2. Exposure was at the wrong level or,
3. A mid-line disk lesion made disclosure difficult
4. A double lesion was found in about 20 per cent of his cases
5. A bilateral lesion requires exposure on both sides

In some cases

6. Insufficient removal permits
7. Further protrusion, or,
8. A previously healthy disk might prolapse

In other cases

9. A nerve root might be damaged or might become adherent
10. There might be arthritis of intervertebral joints

Twenty per cent of a series of cases reported by Lenhard required multiple operations

Many persons operated on for a ruptured intervertebral disk are not relieved of their pain because of

1. The poor selection of candidates or
2. Too early operation

In addition

3. The failure of the surgeon to find and remove all the loose fragments must be considered
4. The disk fragments may occupy many locations
5. They may be in a foramen or,
6. They may migrate up and down the spinal canal

Armstrong finds that one of the commonest causes of failure when a lesion has been found, is a recurrence of a protrusion from the same disk due to failure to remove sufficient material. Young described an "unripe" disk where only part of the nucleus is sequestrated and the remainder is apt to be left behind, with the danger of subsequent extrusion

Neglect of proper medical supervision during the period of recovery from surgery undoubtedly helps to produce unsatisfactory results. Muscular weakness and postural defects should be corrected by a graduated supervised program. Physical activities are increased systematically but are kept within physiological limits of tolerance. Fears and phobias are dispelled with proper reassurance

Adson advised great caution in operating upon persons whose roentgenograms revealed osteophytic lesions of the posterior aspects of the vertebrae

Cloward believes that the most common causes of surgical failures are unstable vertebral joints due to loss of the nucleus pulposus, the existence of other disk fragments herniated beyond the visual limits of the operative exposure, the existence of arthritic spurs encroaching on the intervertebral foramen, and narrowing of the foramen due to encroachment of the articular facet following collapse of the disk

Recurrences are due to errors regarding indication for surgery, diagnosis and operative technic The incidence of post-operative recurrence of symptoms of such severity as to warrant re-operation, in O Connell's series, was 2 per cent

Friberg s experience indicates that lumbosacral fusion is followed by unsatisfactory results in those cases where extensive laminectomies have been performed previously

Five per cent of all disk syndromes are due to spinal cord tumors therefore one should beware of primary fusion

I cannot agree wholeheartedly with those who hold that if fusion of the vertebrae is to be accomplished it should be done at the same operation Key finds it difficult to decide when a spine should be fused and when it should not

Causes of Failure —Following the operative treatment of disk lesions the causes of failure are to be found in the

1 Diagnosis or
2 Procedure

I always ask myself the questions (1) Did I find enough pathology to account for all the patient's complaints? (2) Did I take care of it? (3) What did I overlook? Failure to explore high enough will account for many failures to discover the lesion or all the lesions I am certain that I have seen cases that were not completely relieved because the trouble was higher in the spinal column than was diagnosed by the available methods employed

In some cases, the patient claims he is worse after operation than he was before This may be due to

- A poor selection of subjects
- Premature surgery
- Failure to find a disk lesion
- Failure to remove all loose fragments
- Disk fragments may be scattered

Barr's experience indicates the following factors (1) Wrong diagnosis or incomplete diagnosis, (2) delay in treatment (3) poor selection of cases, (4) poor surgical risks and complications, (5) poorly supervised after-care

In patients with genuine disk lesions who are not relieved by operation, the causes of failure may be one or more of the following factors

1 Failure to locate the lesion
2 Failure to recognize a double lesion
3 Failure to deal with a bilateral lesion

The next three complications also are under the control of the surgeon and arise from the manner in which he deals with an abnormal disk They are

4 Subsequent further protrusion of disk material
5 Nerve root damage
6 Nerve root adherence
7 Subsequent prolapse of a previously normal disk
8 Permanent changes in a nerve root
9 Damage to the posterior articular facets
10 Arthritis of an intervertebral joint

11 Postoperative infection
12 Gross damage to the spinal theca, to the cauda equina or to the extrathecal nerve roots

Failure in cases with positive diagnostic criteria usually results from inability to find or remove all the protruding disk material or from recurrence of the disk protrusion

Armstrong detailed the causes of operative failure as follows

1 Sometimes there was no lesion or, more often,
2 Exposure was at the wrong level, or
3 A midline disk lesion made disclosure difficult
4 A double lesion was found in about 20 per cent of his cases
5 A bilateral lesion requires exposure on both sides

In some cases

6 Insufficient removal permits
7 Further protrusion, or,
8 A previously healthy disk might prolapse

In other cases

9 A nerve root might be damaged or might become adherent
10 There might be arthritis of intervertebral joints

Twenty per cent of a series of cases reported by Lenhard required multiple operations

Many persons operated on for a ruptured intervertebral disk are not relieved of their pain because of

1 The poor selection of candidates or
2 Too early operation

In addition

3 The failure of the surgeon to find and remove all the loose fragments must be considered
4 The disk fragments may occupy many locations
5 They may be in a foramen or,
6 They may migrate up and down the spinal canal

Armstrong finds that one of the commonest causes of failure when a lesion has been found is a recurrence of a protrusion from the same disk due to failure to remove sufficient material. Young described an "unripe" disk where only part of the nucleus is sequestrated and the remainder is apt to be left behind with the danger of subsequent extrusion

Neglect of proper medical supervision during the period of recovery from surgery undoubtedly helps to produce unsatisfactory results. Muscular weakness and postural defects should be corrected by a graduated supervised program. Physical activities are increased systematically but are kept within physiological limits of tolerance. Fears and phobias are dispelled with proper reassurance

Adson advised great caution in operating upon persons whose roentgenograms revealed osteophytic lesions of the posterior aspects of the vertebrae

Cloward believes that the most common causes of surgical failures are unstable vertebral joints due to loss of the nucleus pulposus, the existence of other disk fragments herniated beyond the visual limits of the operative exposure, the existence of arthritic spurs encroaching on the intervertebral foramen, and narrowing of the foramen due to encroachment of the articular facet following collapse of the disk

Barr agrees that patients with local mechanical changes—such as spondylolisthesis, spondylolysis, and subluxation of articular facets—may be relieved of their acute sciatic symptoms by disk excision. However, continued pain and weakness of the back, unless corrected by stabilization of the affected segments, frequently lead to disappointment.

Multiple Disk Lesions.—It has been estimated that in at least 5 per cent of cases, three disks are present at the time of operation, or will subsequently develop. Without a proper appreciation of multiple disks, any operative treatment is doomed to disappointment. This is one of the *principal causes of failures.*

Risks and Complications of Surgical Treatment.—The mortality rate in disk surgery is less than 1 per cent. Adequate preoperative preparation, modern anesthesia, replacement of blood loss, and sound surgical technic have reduced the operative mortality rate in good clinics to the vanishing point. Pulmonary embolism occurring one to four weeks postoperatively accounts for most of the deaths.

Postoperative sepsis occurs in 4 per cent or less, in most reported series. Superficial sepsis may be of little importance, but deep-seated infection of the intervertebral space is serious and leads to prolonged disability. The intervertebral disk is essentially avascular, and symptoms of disk space infection may develop slowly. It is manifested by malaise, pyrexia and painful spasm of the low-back musculature. The white blood count and the sedimentation rate are usually elevated.

Treatment consists in general supportive measures, adequate chemotherapy and splinting of the back by bed rest and a cast, corset, or brace. The prognosis for eventual recovery is good, although the symptoms may persist for many weeks or months.

Operative Damage.—The nerve roots in the spinal canal are shielded from visual inspection by a variety of structures. The integrity and function of the involved segment of the spinal column is probably impaired to some extent in every exploration.

Local strain, instability, fibrosis and hypertrophic change may, in some cases, produce symptoms of back pain and weakness sufficient to force the patient to limit his physical activities. Barr has seen certain patients with postoperative recurrent low-back and sciatic pain who on re-exploration were found to have excessive fibrous tissue reaction with extensive adhesions involving nerve roots, dura, interlaminar and articular structures. Excision of scar tissue, freeing of the nerve roots, and arthrodesis of the involved spinal segments has, in some cases, resulted in permanent relief of symptoms.

Retraction of nerve roots during surgical exploration ordinarily causes no recognizable injury, but occasionally, even in skilled hands, sufficient damage occurs to produce motor weakness or paralysis with resultant foot drop.

The operative result may be unsatisfactory because the surgeon fails to completely remove the displaced disk tissue, or he fails to recognize multiple lesions occurring at more than one spinal level. Double disk lesions are found by some surgeons in 20 per cent of their cases. Barr suggests that some surgeons mistake anatomical variations, such as Schmorl's nodules, for pathological processes.

RECURRENCE OF SYMPTOMS OF PROTRUDED INTERVERTEBRAL DISKS

Recurrence of symptoms can occur after removal of a protruded intervertebral disk. There is, as far as I know, no absolute way to prevent a recurrence at the same site or the occurrence of another protrusion at a different interspace. When a patient has recurrent nerve-root symptoms after removal of a protruded intervertebral disk, usually there is further protrusion of fibrocartilage from the same interspace; rarely another disk is involved.

R. H. Young lists the most probable causes of most of the recurrences and all the failures:

1. A lesion of another disk.
2. Removal of insufficient disk material.
3. Failure to find a lesion when one is present.
4. Postoperative adhesions.

R. H. Young found that those patients who have never been free from pain after operation have either an undiscovered lesion or, more probably, dense and widespread adhesions. (There is some evidence that these adhesions are due to infection.) Burns and Young have a rule that if the person is free from pain for three months following operation, a recurrence is due to another protrusion at the same or a neighboring level. Protrusion at another level is twice as frequent as one at the same level.

A further operation on the same disk may be necessary if insufficient material has been removed. This is not likely to occur where a large part of the nucleus is sequestrated, but is liable to happen in a situation that Young calls an "unripe disk," in which there is no definite demarcation between the "quick and the dead." An "unripe" lesion predisposes to the protrusion of material later.

Suggestions on How to Obtain Better Results. — Aitken and Bradford believe that better results could be obtained:

1. By the use of adequate conservative treatment before any operative procedure is considered.
2. By more careful observation, especially of the mental make-up of the patient.
3. The adoption of primary fusion in cases of demonstrable instability.
4. By the application of the principles of rigid fixation to the fusion operation.
5. By the preservation of the facets if no fusion is contemplated.
6. By the application of common sense in exploratory laminectomies.

Interpretation of Recurrent Attacks. — A new attack may be due to protrusion of another disk. Recurrence of pain does not mean failure of the operation.

Relief of Disk Syndromes Without Removal of Disk Material. — I have seen several persons who had typical complete disk syndromes who were operated upon with extensive exposure and exploration but no disk pathology was demonstrable. They were invariably relieved of their acute symptoms. Some of the possible explanations are:

1. Exploration provided relief.
2. They were not true "disk" cases.

3 The patients were satisfied
4 The patients were reluctant to have further surgery

Re-exploration —Armstrong found that re-exploration was indicated in almost half of all patients in whom a previous operation had failed

Intentional Section of Spinal Nerve Roots —I cannot see the rationale of sectioning spinal nerve roots except in cases of (1) irreparable separation of adhesions, (2) uncontrollable pain, (3) second operation

Deliberate section of a nerve root sometimes is warranted and effective to relieve persisting single nerve-root pain after an operation for a herniated disk The nerve is identified by its dermatome hypalgesia Echols and Rehfeld advise exploration of the intervertebral foramen when no pathologic condition is observed within the spinal canal They feel that section of one or more sensory roots should be considered in every case in which exploration does not disclose a ruptured disk

Pseudarthrosis After Attempted Fusion Operations —The most recent statistics on the percentage of pseudarthrosis in fusion of the spine at the New York Orthopedic Hospital were reported by Smith and associates Since using internal fixation and allowing early walking after two weeks, without other support, the rate of pseudarthrosis in 4th lumbar to sacral fusions, jumped from 24 to 55 per cent These patients are now kept down eight weeks and are supplied with a postoperative spica-jacket followed by a brace

The difficulty of obtaining fusion between the 4th and 5th lumbar vertebræ has altered Smith's practice in treating disk cases at this level Hallock removes the nuclear herniation and does not fuse at this interval, unless the postoperative *x*-rays reveal definitely unfavorable mechanics or localized arthritis rendering continued back pain certain With nuclear protrusions at the lumbosacral interspace, however, he fuses, because at this level, the risk of pseudarthrosis is not great Were it not for the practical difficulties in securing fusion between the 4th and 5th lumbar vertebræ he would fuse there also as he feels that patients *with a damaged intervertebral disk mechanism in the lower lumbar spine* where strain is extraordinarily great will be better off in the long run if they have a fusion of the defective articulations

Friberg finds that when fusion is done from the fourth lumbar to the first sacral segment, there is a much higher incidence of pseudarthrosis than when only one disk space is fused The mere presence of a pseudarthrosis in the *x* ray does not preclude a symptomless, well-functioning back

THE DISK PROBLEM IN THE MILITARY SERVICES

Spurling found that the back problem was one of the most serious of all problems during the training period in the military services He discussed back conditions in the services of the aviator parachute trooper, and the tank trooper The obstacle courses are fruitful sources of back injuries

Spurling advises against operating on a disk in a soldier whose injury is not "in the line of duty However if the injury is "in the line of duty" the operation should be performed, but only by an expert

If I were writing army regulations I would prescribe that no soldier would be operated upon for a disk lesion anywhere but at a center where there are expert orthopedic and neurosurgeons and only after one of each had examined the soldier independently. I would leave the matter of myelography to the expert clinicians rather than to the writers of army regulations. I would have a central group of experts pass on all myelograms taken in conjunction with history, physical and neurological examination, *x* rays and laboratory studies including spinal fluid findings.

On the basis of his experience with protruded intervertebral disks in civilian practice and reports which he received from Fulton and from surgeons closely connected with the military services, Love concludes that the condition of protruded intervertebral disk, with consequent compression of the spinal cord and spinal nerves, is occurring among the armed forces with a frequency sufficient to warrant special consideration. In view of actual conditions of war, injuries to the intervertebral disks can be anticipated, especially in tank, parachute, and air corps troops and in those who use jeeps. The most common "mechanical set-up" is staged when the potential victim's back is in flexion with unusual stress and strain upon it.

A soldier operating a tank or a pilot dive-bombing or landing on an airplane carrier runs considerable risk of injuring his spine.

All injuries to the spine directed against the buttocks while the back is in flexion are prone to produce injury of the intervertebral disks.

Parachute troops and dive-bombing pilots take great risks and may injure their disks. All falls incurred while the person is in a sitting posture are potential causes of these injuries. A special situation obtains when a person who is walking backward, pulls heavy objects toward himself and slips or falls.

In the routine activities of the parachute troops the jerk due to "righting movement" and the jars incurred during unequal landing produce disk lesions.

Contraindications to Operation for a Suspected Herniated Nucleus Pulposus

(*a*) Personality of soldier that warns the surgeon he is dealing with a potential chronic invalid or a malingerer.

(*b*) Clinical improvement with conservative measures.

(*c*) Existence of condition prior to military service.

Technical and Practical Disk Surgery Notes

(*a*) Minimal dissection and division of muscles and ligaments compatible with adequate exposure. Extensive bone removal not necessary. Maximal removal of the herniated nucleus pulposus and fragmented annulus fibrosus recommended as a measure in the prevention of recurrences. Curetting of the space is advised.

(*b*) Postoperative bed rest for two weeks.

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APPENDIX

SOME OF THE EVERYDAY ACTS THAT MAY CAUSE BACKACHE

Raising a window that "sticks" This may occur in the home, office or in a streetcar or train
Kicking a football and connecting, or missing
Missing a step, especially on stairs
Bending down to get your shoes out of a grip
Arising suddenly from a stooped position
Picking up grass on the golf course, to see which way the wind is blowing
Extricating locked auto bumpers
Handling a suitcase in a Pullman car
Sneezing—especially by an asthmatic or hay-fever victim
Climbing a ladder and reaching for objects that are too high
Standing on a stool or chair and slipping
Lifting a heavy child from side to side
When structural iron workers, standing on two beams, lift a keg of rivets
Moving furniture in your office, especially putting a rug under the desk
Slipping on the ice
Shoveling snow
Sitting in a cramped position as when doubled up in a Pullman seat
When surgeons operate for a long time in a cramped position
When dentists stand at the chair for many hours
Sitting in a cramped position in a crowded automobile
Reaching for the soap or sneezing, while sitting in a bath tub with legs outstretched
Stooping to pick up a collar button that rolled under the dresser
Lifting a suitcase or bicycle from a level lower than the one on which you are standing

MUSCLE SPASM

Schlesinger believes that "muscle spasm" represents in part, purposeful protective splinting of involved neural elements Therefore reduction of muscle spasm will not necessarily increase the range of motion during the acute phase of a lesion Muscle spasm produces

1 Pain on motion
2 Hyperactive or exaggerated stretch responses
3 Disorganization of reciprocal innervation and synchrony of discharge
4 Hyperesthesia with muscle soreness
5 Autonomic nerve changes

Myanesin a specific muscle relaxant is capable of rapidly dissolving muscle spasm in the "acute disk syndrome" A series of patients with acute low-back and radicular pain were studied before and after the injec-

(*c*) Return to light or full duty in six weeks

(*d*) Use of physical therapy—massage and muscle setting exercises—after first week in bed

(*e*) Recognition of possibility of multiple herniations of nucleus pulposus

(*f*) Recognition of value of bone grafts and spinal fusions in few instances Primary spinal fusion at time of disk removal not recommended except in unusual circumstances

(*g*) Use of back braces, jackets and corsets of doubtful value

(*g*) Use of foot-drop splint indicated where palsy exists

(*i*) Recognition of the fact that the prime indication of "disk surgery" is *pain*

(*j*) The standard diagnosis shall read (1) Herniation of nucleus pulposus (2) Rupture of annulus fibrosus of the intervertebral disk *In recognition of the fact that only a fraction of all lame backs are due to spinal root compressions, it is* RECOMMENDED *that neurosurgeons concern themselves only with that group that fail to respond to usual orthopedic measures or have definite sciatic or other root pain*

Ten Commandments of Treatment of Disk Lesions

1 Give every patient the benefit of conservative treatment

2 Set a deadline for the duration of conservative treatment in each case

3 Do not make drug addicts in order to avoid surgery

4 Do not procrastinate until the patient is a physical and mental wreck

5 Operate during an attack

6 Operate only on request of patient

7 Once you have decided to operate, explore until you can say —

(*a*) I found enough to account for all your trouble

(*b*) I took care of everything that was out of order

(*c*) I anticipate an excellent recovery

8 Demand visual demonstration of local pathology and its damaging effects Do not cut into a normal disk

9 Do not curette a disk like you would a uterus

10 Never fuse a spine at primary operation unless you are more than reasonably certain that you are not "locking in" some pathology especially a spinal cord tumor or a disk at another level or loose fragments in the operated disk

irreducible root compression. Patients with the second type of reaction formed an intermediate group, some required surgical treatment, others responded to conservative management. Thus, in all but the second group, the mephenesin test had definite prognostic value as far as the response of the immediate attack to therapy was concerned.

In group I, with 8 patients followed for a year or more, there was but 1 case requiring surgery. In group II, early operation was required by 5 patients and surgery after six months, by 3. Six of this group were followed for six months or longer. All the 26 patients in groups III and IV required early surgery. Their operative records revealed evidence of root compression of such degree as to make conservative efforts at decompression unfeasible.

Mephenesin offers its greatest benefits for cases of reversible root compression in which muscle spasm plays a large part, in perpetuating the syndrome. It also provides an excellent diagnostic clue to the results that may be expected from conservative treatment. Where a response to mephenesin occurs, even though the effect may be of brief duration, the muscle relaxation initially achieved, may hasten the response to conventional methods of treatment.

An accurate prognosis can spare many patients the economic burden of long periods of useless conservative therapy while assuring others, who are likely to benefit from it, of an adequate trial of nonsurgical therapy.

In large doses, mephenesin can produce paralysis. Therefore it must be given cautiously and only to hospitalized patients who do not show muscular weakness or serious neurologic disturbance. In these experiments a 2 per cent solution administered intravenously produced no serious side effects. Given orally, the drug proved unsatisfactory in the hands of these investigators.

The muscle relaxation produced by mephenesin has also been found helpful as an adjunct to traction and in the relief of pain in various low-back syndromes. It appears likely however, that the drug will have its greatest usefulness in differential diagnosis and prognosis.

One hundred cubic centimeters of a 2 per cent solution is the average dose. They give it either by the drop method or by the direct *injection* with a 50 cubic-centimeter syringe. It is given slowly.

When given too abruptly, there may be a marked effect on the bowels with nausea and vomiting. The 100 cubic centimeters is usually given in about five minutes, rapidly enough so that the effect is maintained, but not fast enough to abruptly bring on toxic symptoms. If a test tells nothing more than when to operate and when not to, *it will be one of the biggest contributions science has had for a long time.*

Severe muscle spasm which represents a secondary protective splinting action following local trauma to the vertebrae and supporting structures, is a major factor in the production of pain and disability. The muscle spasm appears to perpetuate the symptoms by fixing the involved parts in an abnormal position. Muscle spasm which holds adjacent vertebrae firmly together increases the bulge of the protuberant disk, the stress upon the limiting ligaments and the apophyseal joints and consequently the pressure on the nerve root.

tion of this drug It was found that pain and limitation of motion of the limb could be altered with gratifying symptomatic relief If there was an abrupt return of pain and limitation of motion as soon as the drug concentration dropped below therapeutic levels, such patients invariably failed to respond to conservative treatment

There is no doubt that muscle spasm plays a major role in the production and the continuation of pain A vicious cycle is initiated by irritative or reflex factors This causes pain and produces internal splinting which, in turn, increases the pain This produces more splinting, and a vicious cycle is set up It is easier to break this cycle at the point of spasm than at the inception of the cycle, or the end-result of spasm

Lipow found that the action of d tubocurarine chloride at the myoneural junction was immediate and the spasm was markedly diminished

A preparation of d-tubocurarine in wax and oil has been used with some success Myanesin (tolserol) is used in conjunction with d tubocurarine chloride They enhance the value of each other

Treatment by single or repeated doses of d-tubocurarine chloride were supplemented by other methods for the relief of backache in over 100 cases with good results It is not an office procedure

Signs of incoordination occur Atropine in conjunction with morphine may hasten or aggravate the toxicity of curare

(Prostigmine methylsulfate should always be available as an antidote)

This method is extremely valuable when traction is used The relief is noted usually ten to fifteen minutes after injection and increases for the next hour or two Occasionally the relief is permanent but more often, some return of pain is to be expected

Schlesinger and Stinchfield reported on the use of mephenesin as a diagnostic and prognostic aid in acute disorders of the lower back They administered the drug intravenously to 64 hospitalized patients with acute symptoms and signs of herniated intervertebral disk and observed its effect on the pain and on the results of the straight-leg-raising test Four types of reaction were noted

1 Abrupt relief of low-back and sciatic pain and striking increase in the range of leg motion

2 Abrupt relief of pain with only slight or moderate increase in range of leg motion,

3 Abrupt relief of pain with no increase in motion, and

4 Rapid relief of local pain paradoxical aggravation of radiating pain and decrease or no change in straight-leg-raising ability

Patients with the first type of reaction often obtained persistent relief following the administration of mephenesin and a high percentage left the hospital symptomatically well after a period of conservative treatment These patients, some of whom showed unequivocal myelographic evidence of herniated intervertebral disk, were regarded as having reversible nerve root compression possibly aggravated by reflex muscle spasm Patients with the third or fourth type of reaction to mephenesin invariably failed to respond to subsequent conservative treatment Everyone in this group required surgical intervention within three months At operation in each case, there was found a large protrusion of an intervertebral disk producing

a striking increase in range of motion both of which were maintained for varying periods The response in this group was dramatic The 13 patients in group II experienced an abrupt relief from pain and a moderate or small increase in the range of motion for periods of time that were usually of shorter duration than those in the first group In group III there was immediate relief from pain without increase in the range of straight leg raising In these patients pain recurred on cessation of the injection Patients in this group were believed to represent cases in which root compression was direct mechanical in type, and not amenable to the effects of muscle relaxation In group IV there was rapid relief of back pain and tightness but with an increase in radicular pain Relief of pain was of short duration and there was no increase in range of motion of the leg This effect Schlesinger and Stinchfield believe, indicated marked root compression

Response to Tolserol given intravenously If the improvement of the Lasègue test is transient it is a waste of time to treat the patient conservatively (Schlesinger) Tolserol produces muscle relaxation which would in higher degrees lead to paralysis The antidote is adrenalin In contrast to curare, myanesin acts not only peripherally but also on the spine It is not entirely harmless The advantage which seems to lie in myanesin treatment is the promptness of relief of the spasm and the pain associated with it Steindler believes that its main value lies in the differential diagnosis

There is a type of disk herniation that does not recede on relief of the muscle spasm

A COMPARISON BETWEEN THE BACK AND THE KNEE—SIMILARITY OF INTERVERTEBRAL DISKS AND KNEE MENISCI

Several times during the writing of the book on the Knee, I was impressed with the many points of similarity between the knee and the back Both structures are subject to mechanical forces producing strains and sprains Both are subject to internal derangements In both some sensitive structure gets caught and pinched as in the jaws of a nutcracker

Synovitis of the vertebral articulations has its counterpart in synovitis of the knee

There are many interesting analogies between the menisci of the knees and the intervertebral disks I have had several patients who had both concurrent or recurrent meniscus disorders and intervertebral disk syndromes

It is interesting to note the similarities existing between the spine and the knee Both structures are subject to mechanical forces producing strains and sprains Both are subject to internal derangements In each a structure gets caught and pinched as in the jaws of a nutcracker

There are points of similarity between a sprain of the knee and a sprain of the back The mechanogenesis is usually a leverage force rather than a direct blow Flexion plus a rotary twist (or lateral shift) One part is stabilized another part is twisted

Mephenesin, in a 2 per cent solution, given intravenously produces an abrupt relaxant effect which can be controlled and maintained by adjusting the rate of the injection. The effect is manifested by flushing about the mouth, slightly blurred vision, pleasant relaxation, and a dramatic degree of relief from pain.

Mephenesin has been tested by Schlesinger and Stinchfield in a series of 64 patients with acute low-back and radicular pain. It has been found that pain and limitation of motion of a leg can be altered with gratifying symptomatic relief in a high percentage of cases. Failure to respond to conservative treatment, is an indication for surgical intervention.

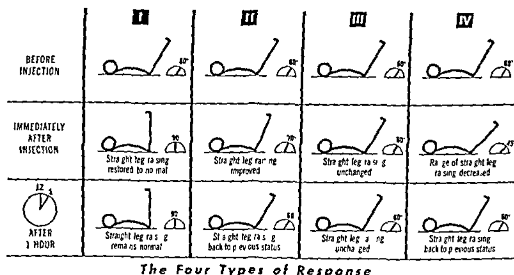


FIG 371 —The reactions to the injection of myanesin fell into the following categories (Chart 1) (1) In Group I there were an abrupt relief from pain and a concomitant striking increase in range of motion (2) In Group II there were also an abrupt relief from pain and a moderate or small increase in the range of motion for varying periods of time usually of a shorter duration than that in the first group (3) In Group III there was an abrupt relief from pain with no increase in the range of straight leg raising In this group however there was an equally abrupt return of pain on the cessation of injection (4) In Group IV there was rapid relief of back pain and tightness but with an increase in radicular pain The relief from pain was of short duration Their ability in straight leg raising never increased and on occasion even decreased (Schlesinger and Stinchfield courtesy of Jour Bone Jt Surg)

Only patients with the diagnosis, physical signs and severe complaints of intervertebral disk lesions were studied. Soon after admission to the hospital, each patient was given an intravenous injection of approximately *100 cc of 2 per cent solution of mephenesin.* *Before the injection* the patient's ability to raise his straight leg was recorded. After the injection was begun and as soon as the level of vertical nystagmus had been reached the patient's ability at straight-leg raising was once more tested both for actual range and for the point at which pain could be easily elicited. The injection was then continued to 100 cc with repeated testing of the range of straight leg raising. There was no forced elevation or manipulation.

The patients were classified in four categories according to response. In group I, consisting of 25 patients there occurred prompt relief of pain with

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Mephenesin, in a 2 per cent solution, given intravenously produces an abrupt relaxant effect which can be controlled and maintained by adjusting the rate of the injection The effect is manifested by flushing about the mouth, slightly blurred vision, pleasant relaxation, and a dramatic degree of relief from pain

Mephenesin has been tested by Schlesinger and Stinchfield in a series of 64 patients with acute low-back and radicular pain It has been found that pain and limitation of motion of a leg can be altered with gratifying symptomatic relief in a high percentage of cases Failure to respond to conservative treatment, is an indication for surgical intervention

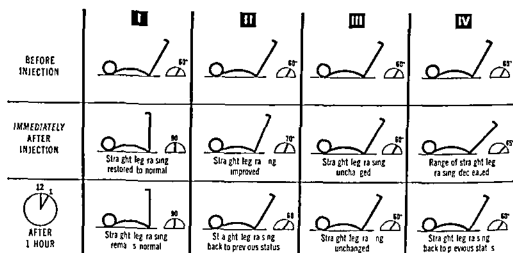


FIG 371 —The reactions to the injection of myanesin fell into the following categories (Chart 1) (1) In Group I there were an abrupt relief from pain and a concomitant striking increase in range of motion (2) In Group II there were also an abrupt relief from pain and a moderate or small increase in the range of motion for varying periods of time usually of a shorter duration than that in the first group (3) In Group III there was an abrupt relief from pain with no increase in the range of straight leg raising In this group however there was an equally abrupt return of pain on the cessation of injection (4) In Group IV there was rapid relief of back pain and tightness but with an increase in radicular pain The relief from pain was of short duration Their ability in straight leg raising never increased and on occasion even decreased (Schlesinger and Stinchfield courtesy of Jour Bone Jt Surg)

Only patients with the diagnosis, physical signs, and severe complaints of intervertebral disk lesions were studied Soon after admission to the hospital, each patient was given an intravenous injection of approximately 100 cc of 2 per cent solution of mephenesin Before the injection the patient s ability to raise his straight leg was recorded After the injection was begun and as soon as the level of vertical nystagmus had been reached the patient s ability at straight leg raising was once more tested, both for actual range and for the point at which pain could be easily elicited The injection was then continued to 100 cc with repeated testing of the range of straight leg raising There was no forced elevation or manipulation

The patients were classified in four categories according to response In group I, consisting of 25 patients there occurred prompt relief of pain with

STOCKHOLM CONGRESS

An important record of the present consensus of some of the world's authorities is contained in the resume of the Fifth Congress of the International Society of Orthopaedic and Traumatic Surgery held in Stockholm on May 21, 1951. This report is found in the Journal of Bone and Joint Surgery, Vol 33-B:621, October 1951. It is recommended to the reader.

One of the most instructive reports was made by Barr who presented statistics on 50 cases treated by disk excision alone and 50 treated by excision and immediate fusion. Of 50 cases with excision of disk alone 56 per cent had no sciatic symptoms, 12 per cent had mild symptoms. Of 50 cases with excision of disk and immediate fusion 68 per cent had no symptoms, 28 per cent had mild sciatic symptoms.

Hirsch reported on his anatomical studies of lumbar disks. Degenerative changes were found so frequently they were considered more or less physiological. The initial process was found to be degeneration in the nucleus with secondary changes in the annulus. No evidence of healing of a disk was found. Hirsch described mechanical experiments made with a special apparatus to register the deforming forces, both as to direction and magnitude, in the different parts of the disk when subjected to pressure. In normal disks no variation was found, while in degenerated disks there was considerable variation in the several disks and in different parts of the same disks. In studies of disk puncture, only a fraction of a cubic centimeter of material could be injected into a normal disk while a degenerated one would accommodate 1 to 2 cubic centimeters. Raising the intradiskal pressure would reproduce the patient's pain in cases of lumbago. Hirsch presented evidence to support the view that lumbago is the result of a functional disturbance in one or more disks producing irritation of the sensory endings in the longitudinal ligaments.

Sylven reported on electromicroscopic studies of the normal nucleus pulposus in man and in young calves. By fractionation procedures, the matrix was found to consist of collagen fibrils, a polysaccharide, a protein component attached to the polysaccharide and water. These elements formed a three-dimensional lattice gel system with a water content of 83 per cent. The polysaccharide appeared to be chondroitin sulphuric acid. These polysaccharides are presumed to be chemically linked to the surface of collagen fibrils rendering them hydrophilic by virtue of their polar groups. Diffusion studies revealed that simple diffusion cannot fulfill the nutritional requirements and some other transport mechanism must exist. Degenerative changes were found to appear in the third decade. Large collagen bundles appeared. It was felt that these changes implied marked alterations in the gel lattice.

Knutsson employed a water-soluble 20 per cent abrodil solution for lumbar myelography. Over 900 examinations with 8 to 10 cubic centimeters have been performed. The advantages of the method included superior detail with excellent visualization of the root sheaths and the ready absorption of the material, so that removal was not necessary. The material is an irritant, requiring preliminary spinal analgesia with 1 cubic centimeter

THE "CHRONIC" LAME BACK

The "Chronic" back is characterized by pain, stiffness, instability, undependability and unpredictability

The basic causes of instability may be (1) Mechanical, (2) arthritic, (3) infectious, (4) traumatic, or (5) nutritional

The basic tissues or structures involved may be (1) bones or (2) soft tissues

The usual complaints are (1) Discomfort, (2) deformity, and (3) disability

The chief types of chronic disorders are 1 Painful backs

2 Deformed backs—Scoliosis—Tuberculosis — Poliomyelitis—Scheuermann's Lesion

3 Disabled backs are (a) Inadequate backs, (b) incompetent backs, (c) undependable backs

The syndrome called "Lame Back" is comparable to the one called "Weak Kneed" The person with a lame back is not always a "spineless individual"

Conservative treatment includes Ethyl chloride spray, massage, injection of trigger areas, adhesive strapping, brace, corset, x ray therapy If these fail, surgery is indicated

Formerly many orthopedic surgeons would say "Wait till you see how many simple disk removal cases will need subsequent fusions ' Some neurosurgeons were saying, If you only knew the number of fused spines that should have had disk removals first''

I would like to know How many "disk-operated persons return for fusion? How many fusion-operated' persons return for disk operation? How many cases of fusion still require exploration? How many disk operated persons are finally relieved by fasciotomy?

The reader is advised to read a book by Delitala and Bonola entitled ' Hernia of the Disks and Vertebral Sciatica " This book represents the Italian concept of this important subject The authors reviewed 7000 cases of arthritis and "sciatica' that have been treated at the Rizzoli Institute for Orthopedic Surgery They have operated on 217 patients and have followed 170 of them for periods of several years The results were excellent in 34 per cent of the cases There were no recurrences Results were satisfactory in 31 per cent of the cases fair in 25 per cent and mediocre in 8 per cent of the cases About 1 per cent of patients received no benefit whatsoever

The authors studied the mechanism by which protrusion of an intervertebral disk may be determined experimentally They believe that when a person changes from the horizontal to the vertical position the nucleus pulposus is subjected to a pressure of 45 Kg When he passes from flexion to extension, the nucleus sustains a pressure of 90 to 127 Kg

"SEEING IS BELIEVING" AND ONLY SEEING IS BELIEVING

The general practitioner has done his share by thinking about the disk syndrome and requesting help in the diagnosis and treatment. The specialist agrees with the general practitioner who maintains an open mind regarding clinical disk disorders.

Nothing will convince the general practitioner of the precise clinical diagnosis and uniformly surgical benefits in disk disorders as positively as witnessing a few operations. Every general practitioner should attend at least two operations for disk derangements performed on those patients whom he has studied before he referred them to surgeons.

The records of 15,160 patients seen in Friberg's Clinic for lumbar pain excluding those with tuberculosis and tumors, during the period 1936 to 1946, have been collected. In addition to their physical observations they studied the incidence of radiographic signs of disk degeneration in the lumbar spine.

From a study of over 9000 radiographs from patients with low-back pain, Friberg and Hirsch showed that 39 per cent of all cases showed evidence of disk degeneration. Their anatomical investigation of 500 lumbar intervertebral disks showed that definite changes, with rupture of the annulus fibrosus, could occur in many cases without evidence of any change in the radiograph. Thus, a normal radiograph in no way excludes the possibility that the patient's pain originates in a disk derangement.

Pain in a lower extremity may be due to compression of a nerve root at an intervertebral foramen. One or all of the following may be responsible for nerve root pressure: (*a*) Herniation of the torn fragments of an intervertebral disk or bulging backward of the nucleus pulposus into the spinal canal.

(*b*) Narrowing of an intervertebral foramen by subluxation of the articular facets following collapse and narrowing of the intervertebral space.

(*c*) Proliferation of bone along the margin of a body of a vertebra posteriorly (osteophytes) encroaching upon the intervertebral foramen.

(*d*) Hypertrophy of the ligamentum flavum which, with a facet, forms the posterior boundary of the intervertebral foramen.

of 5 per cent procaine. Complications encountered included transitory nausea, shock, unconsciousness, and epileptiform cramps.

Herbert advocated the use of epidural myelography. By careful study of different projections, with the patient standing in flexion and extension, valuable evidence was obtained. He condemned the use of lipiodol intradurally. He stressed the importance of clinical diagnosis and of deferring surgical treatment for four to five months after the onset of symptoms so that the herniation would be mature. He found that spine fusion after disk removal gave the best results.

Lindblom described the technic and results of diagnostic disk puncture, made by injecting 2 cc. of a 35 per cent diodrast with 0.25 cc. of 5 per cent. procaine under fluoroscopy, using a double needle. The normal disk accommodates 0.5 cc. of fluid, while pathologic disks accept more. This method made it possible in some cases to demonstrate that the back pain originated in one disk while the sciatica was due to a disorder in another. Distention of a normal disk produced local pain, while that of an involved disk reproduced the patient's low-back and sciatic symptoms. Normal and abnormal diskograms were readily visualized. There was no evidence that disk protrusion ever resulted from the procedure.

Erlacher pointed out the advantages of nucleography. These included information as to the shape and situation of the nucleus within the disk, the size of a herniation, and the degree of degeneration of the annulus. He found that this method often gave information where myelography failed.

Charnley, in a report on experiments concerning the swelling of the nucleus pulposus in isotonic saline, found this phenomenon to be greater in this tissue than in any of the others tested. Although there were marked variations, some disks increased their volume 50 per cent at the rate of 10 per cent per hour. The expanding tissue exerted pressures of 100 to 150 millimeters of mercury. Charnley postulated that acute episodes of the lumbago-sciatica syndrome might result from acute swelling due to imbibition of intercellular fluid.

The incidence of prostatic carcinoma is high while carcinoma of the seminal vesicles is remarkably low. On the other hand, infections of the prostate are usually associated with similar infections of the seminal vesicles but vesicle infections are often associated with non-infected prostates.

Clinical observation has forced the conclusion that metastatic infection from the male genital glands is from the seminal vesicle only. There are three definite areas of the back that may be involved in painful symptoms due to infections of the prostate and seminal vesicles. The most common area for either an acute or chronic type of pain is over one or both sacro-iliac synchondroses, the next most common is the lower thoracic region and the least common is the upper thoracic region. These locations are important in the order mentioned whether pain is caused by metastatic infection by toxin or is referred. It has been stressed that such backaches are more pronounced in the morning. Sometimes on awakening and moving about patients are very uncomfortable but improvement is noted on increased movement and gradually, as the day proceeds, the pain is relieved.

Pain in the back is variously described by the patient as an ache, dull pain, soreness, stiffness, burning, a bearing-down sensation, a tired feeling or a dragging sensation.

In metastatic infections to the back definite areas of tenderness may be felt in accord with the symptoms while roentgen studies may reveal nothing unless late changes have developed. The outstanding therapeutic test is the almost immediate relief of reflex back pain caused by distended prostatic acini from lack of drainage of infected materials when drainage is established by adequate massage.

Surgical drainage of the seminal vesicles is no substitute for careful intelligent, systematic massage for these conditions with intervals of a week between treatments and pressure within therapeutic reason. Local treatment should be continued until the pus cells have been greatly reduced, active spermatozoa and normal amounts of fat bodies re-appear in the expressed fluids and metastatic or referred symptoms completely disappear.

Emphasis should be placed here on infected teeth, tonsils and sinuses. Eradication of other foci of infection is often followed by success in the management of genital infections which had previously resisted adequate local treatment.

Carcinoma of the Prostate

Carcinoma of the prostate assumes an increasingly more important position as a cause of back pain. Twenty to 25 per cent of all cases of chronic bladder-neck obstruction are caused by carcinoma of the prostate. Carcinoma of the prostate produces back pain in two ways, *i. e.* by reflexion of pain impulses from intraprostatic pressure and infiltrations and by metastasis to bone. Metastases for the most part occur by way of the lymphatics which accompany the nerves, hence a great number of obscure pains of the back and hips, and sciatica-like leg pains may occur with or without bone involvement. The strong tendency for carcinoma of the prostate to produce bone metastases must always be kept in mind.

LESIONS OF THE GENITO-URINARY TRACT IN RELATION TO BACKACHE

The specialties of orthopedic and urological surgery have several conditions in common these are especially gonorrheal, syphilitic and tuberculous The most important genito-urinary complications which the orthopedic surgeon is called upon to treat include tuberculosis and arthritis of the spine The important metastatic lesions are gonorrheal, tuberculous and neoplastic A compression fracture of the spine often produces a "cord bladder" which may be followed by an ascending infection to the kidney The differential diagnosis between urinary tract calculi and hypertrophic spondylitis with radiculitis, may offer some difficulty

Diseases of the genito-urinary tract have a definite bearing on low-back pain The genito-urinary system is frequently overlooked as a possible factor in the production of back pains

Prostatitis and seminal vesiculitis are the lesions most commonly overlooked by expert medical men

UROLOGICAL ASPECTS OF LOW-BACK PAIN

By Harry Culver M D Chicago

The kidney lies extraperitoneally opposite the area from the 11th thoracic to the 3d lumbar vertebræ It derives its innervation from the renal plexus of the sympathetic system along the renal artery It receives fibers also from the 11th and 12th spinal nerves

Kidney pain may be caused by any force which stretches the renal capsule Ureteral pain is due almost entirely to spasmodic muscular contractions caused by the presence of a foreign substance or by regional ureteritis ureteral kinks strictures or extra-ureteral pressure sufficient to produce partial obstruction Pressure on surrounding tissues from abnormally *placed or abnormally large kidneys produces local pain as does their* adherence to and traction on the adjacent parietal peritoneum

Referred pain is common in kidney and ureteral disturbances Abnormally low-lying kidneys may produce low-back pain The pain may be referred to the back only or to both the back and the front

Stone formation is prone to follow renal pelvic stasis and infection A neoplasm of a normally placed kidney with metastasis to bone may cause some confusion in diagnosis Pain produced by bladder lesions may occur when a bladder neoplasm partially obstructs a ureteral orifice, resulting in upper urinary tract dilatations

Diseases of the prostate and seminal vesicles produce a large majority of low back complaints which are concluded to be primarily urological

Diseases of the prostate and seminal vesicles may cause low back pain in three distinct ways (1) by metastasis of infectious or neoplastic tissue from foci within the prostate and seminal vesicles (2) by blood borne toxins from infectious foci within the prostate and seminal vesicles and (3) by reflex nervous impulses originating within these structures due to intraprostatic or seminal vesicular pressure or adhesions

The incidence of prostatic carcinoma is high while carcinoma of the seminal vesicles is remarkably low. On the other hand, infections of the prostate are usually associated with similar infections of the seminal vesicles, but vesicle infections are often associated with non-infected prostates.

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Pain from metastasis is best controlled by 1 Appropriate doses of estrogenic substances,

2 Castration, to remove the chief source of androgen which substance stimulates the activity of the neoplastic process,

3 Combination of 1 and 2 in a manner determined to be the most beneficial in the experience of the operator

4 Deep roentgen-ray therapy still has a place here when judiciously used after the first two procedures have failed to give a completely favorable response

Where recurrence of pain has developed following successful use of the above methods of management, that benefit may be obtained by bilateral adrenalectomy

Gordon found that 31 per cent of more than 3000 urological patients had backache Backache of renal origin may occur on either one or both sides of the vertebral column According to Morris, Langlois and Brunton, in the majority of cases the disability is bilateral with eventual involvement of both kidney pelves

In cases of backache due to renal reflex, the pain is deep-seated in contrast to the more superficial conditions of myalgia and neuralgia

Persons confined to bed for prolonged periods in the supine position are particularly prone to develop calculi in the genito-urinary tract In practically all cases of renal calculus with backache, the pain is localized to the costovertebral region Ureteral calculus produces a marked tenderness in the lumbar and costovertebral region, with associated tenderness in the abdomen over the region of the involved ureter at the site of the stone Pain in these cases is usually referred to the flank

Prostatitis is the most commonly overlooked lesion by expert medical men in attempts to explain the cause of backache in their male patients An infected prostate cannot be ruled out as a cause of low backache in a man until the seminal vesicles and prostatic secretions have been proved negative on three successive occasions Digital examination is not sufficient and should be supplemented by a microscopic examination of the secretions The prostate must be emptied by massage to obtain the secretion Secretions from an infected prostate reveal pus cells diminution of lecithin, fine hyalin granules and degenerated cells There is also a lack of motility in the spermatozoa

Tuberculosis is of interest to the urologist as well as the orthopedic surgeon because many of the bone and joint conditions are secondary to tuberculosis of the genito-urinary tract especially the kidney, testis and the epididymis Many of these urological conditions are secondary to osseous lesions but more often the bone condition is secondary to the genito-urinary infection

Jaffe states that many urologists think that tuberculosis originates in the seminal vesicles, some believe it originates in the epididymis and others in the prostate

The backache accompanying prostatovesicular infection follows a definite pattern The complaint in practically every case is that of sacral pain If the pain is referred it usually follows the course of the sciatic nerve occurring more rarely along the inner aspect of the thigh and groin A

patient with prostatic backache describes his pain as most pronounced on arising, but as lessening with activity and subsiding as the day progresses. It is a dull aching type of pain aggravated in many instances by sexual excitation.

If one investigates, he will find the primary focus in the lungs. I have seen cases where a tuberculous spine became manifest several months after a tuberculous kidney was removed. It is therefore wise for the urologist to investigate the spine, especially the lower thoracic and upper lumbar regions, in every case of tuberculous kidney, because of the proximity of the kidney to the spine and the lymphatic and blood circulations.

Tuberculosis of vertebral or sacro-iliac joints may produce secondary foci in the genito-urinary tract as in epididymitis. I had one patient who developed tuberculosis following a lumbosacral involvement, which required removal of one testis, vas deferens and epididymis. It is probable that in these organs the disease spreads by contiguity as well as by means of blood or lymphatic circulations.

Carcinomatous metastases from the bladder and prostate to the bone are discussed in Chapter 29. Sciatica caused by carcinoma of the prostate is usually unilateral.

Treatment of Paralyzed Urinary Bladder

Treatment of a paralyzed bladder is determined by the causative factors and by the anatomical location of the spinal lesion. With complete destruction of the spinal paths the urinary retention should be permitted to overflow, if possible. If this fails catheter drainage will be necessary. If destruction is only partial, the bladder function may return to normal gradually. Such natural return of function may be insured by preliminary catheter drainage rather than by development of an overflow bladder.

The danger of a secondary infection with resulting ascending pyelonephritis is real regardless of the form of treatment. However by employing modern aseptic precautions and with the aid of chemotherapy serious infection can in many cases be prevented. But on the battlefield, catheter drainage should be postponed if possible. Tidal drainage as suggested by Munro, has been successfully employed in some cases. Section of presacral sympathetic nerves has been recommended.

UROLOGICAL CONDITIONS IN THE FEMALE

Gynecological Conditions That May Cause Backache.—In the female, pregnancy, the adnexa and a wide pelvis are special factors in the causation of backache. *Culbertson found* that it was the consensus of most gynecologists that not more than 33⅓ per cent of the backache of which women complain, was due to the pelvic organs.

Gynecological conditions can be placed in three groups. First, displacements. Unquestionably *some retroversions of the uterus are associated* with backache, which is relieved when the retroversion is corrected. Second, pelvic inflammations, including perimetritis, puerperal infection and general

pelvic peritonitis Third, tumors—particularly those which are imbedded in the pelvis or are large enough to produce pressure symptoms In the majority of women who complain of backache the cause is found to be due to conditions outside of the pelvis

The most important condition requiring "team work" by the orthopedic surgeon and the gynecologist is low-back pain, especially when due to lumbosacral and sacro-iliac strain which may be accompanied by arthritis or "sciatic neuritis A corset firm headed an advertisement "A woman is a creature with a pain in her back

Sturmdorf described gynecopathic myospastic backache in women, and backache associated with retroversion Ballard found that in 15 of every 100 patients operated on for gynecopathic conditions and cured of them, the backache still persisted

The gynecologist must be very careful in recommending pelvic operation for low-back pain because in many cases the pain persists after operation

Trauma to the Back During Gynecological Operations —In a plea for greater care in arranging patients on the operating table for the prevention of the common post-operative painful back Goldthwait called attention to the importance of considering the position in which patients are placed during the performance of operations, so that the sacro-iliac joints and those of the lumbar spine should not be strained It should be remembered that when lying on the back, if the bed or supporting structure is hard so that the buttocks cannot settle into it the lumbar spine must sag downward If the buttocks are large and the waist small the amount of this sag may be enough to cause painful strain on the interspinous ligaments or on the sacro-iliac joints

Discussion of Gynecological Causes —Backache is one of the most common complaints in women and according to Davis its cause is usually referred to the reproductive organs Acquired retrodisplacements of the uterus will produce lumbosacral backache but abnormalities of the pelvic girdle and its intricate supporting structures are more common causes of backache than retrodisplacements In the routine pelvic examination of young women, symptomless retroversions of the uterus are found frequently They are not likely to interfere with normal physiological function of the reproductive organs Retrodisplacements often follow childbirth The weight of the uterus during the puerperium the relaxation of the supporting structures and the trauma to the pelvic floor and the ligaments and fasciae of the uterus contribute to the malposition Backache may make its first appearance during the postpartum period

Childbirth is likely to produce backache of pelvic origin The pelvic *joints become more movable during pregnancy* and labor as a result of an increased separation of the pelvic bones The added load of the baby and the altered posture and gait provide increased stresses and strains on the keystone of the bony framework Uebermuth believes that the overburdening of the female vertebral column during pregnancy is a common cause of disturbances of the intervertebral disks which produce backache Separation of the symphysis pubis and changes in the sacro-iliac joints and more rarely in the sacrococcygeal joint are aggravated by long labors and difficult operative procedures In most women, these pelvic changes

rapidly disappear after delivery; in many, residual changes also rapidly disappear after delivery but in some residual changes persist and cause chronic low back pain.

Davis finds that in the first few months after childbirth acquired retroversions can be successfully corrected by a proper pessary and exercises. Retrodisplacements not associated with childbearing are, however, not amenable to permanent cure. It will indicate its return to the former position by a return of the patient's backache. Surgical correction of the malposition is indicated if the backache is definitely of uterine origin and the discomfort interferes seriously with the patient's welfare, also if it is not expedient to wear a pessary.

Adherent retrodisplacements are more difficult to evaluate for diagnosis and treatment. Inflammatory conditions of the adnexa often result in adnexal masses which drag the body of the uterus posteriorly as they slowly retrogress.

MEDICO LEGAL ASPECTS OF BACK DISORDERS

On this general subject, I quote with permission from the Honorable John Clark Knox, LL.D., Chief United States District Judge for the Southern District of New York.

"The practice of medicine, like the practice of law and other professions is sometimes accursed by men of base natures and the characters of charlatans. These sometimes subject the art to the suspicion that it is but little more than a mercenary trade. The quack and the fraud is to be found both within and without the court room. On the highways and byways of life, he preys upon the ignorant and unwise. Within the halls of justice, he perjures himself upon the altar of truth, and reflects discredit upon the guild in which he claims membership. At times he raises doubt in the minds of intelligent men as to whether medicine in general, and psychiatry in particular, have any real claim to a scientific basis. Day after day, we find physicians arrayed on opposite sides of a lawsuit. Each will be given the same set of facts, and asked to draw a reasonable conclusion from the evidence before him. Very often the opinions expressed by the opposing physicians are as far apart as the poles, and in all too many instances, these opinions are determined not by the facts, but by the necessities of the litigant retaining the physicians who gave them utterance. A doctor, it is true, is under great obligation to his patient, and a lawyer, undoubtedly, owes an understanding duty to his client, but the obligation of one and the duty of the other, is no justification for the prostitution of the law and the rightful expectations of organized society.

"There is, however, no higher duty upon the part of the upright lawyer and the straightforward physician than that each should protect the honor and integrity of the profession to which he belongs."

Examinations and Reports

Thoroughness is the watchword and test of sincerity in preparing full information pertaining to a case of personal injury. Lawsuits are frequent in such cases and it is fully within the field of medical practice to obtain accurate information about the facts such as would throw light upon the responsibility for the injury. Inquiry should be made for the names of persons and about circumstances regarding the accident to make clear the details, locations, magnitude of forces that caused the accident and other facts relative to the manner of occurrence. Details of observation are important. The size, location, shape, direction and all other appearances should be investigated fully and recorded accurately. Failure to make a record of a very trivial circumstance or the appearance of a wound may later be the deciding factor in a legal controversy.

All physical defects other than those caused by the present injury should be observed, examined and recorded. Inquiry should be made into the past history relative to previous accidents and disabilities. Otherwise some previous injury may be brought in as evidence of present injury or some future development may be the result of a past injury and yet claim made that it developed from the present injury.

The report of injury should be complete yet concise. The nature of the symptoms is said to be subjective only in a case where no wounds can be seen nor any objective findings discovered and where the roentgen ray and other laboratory tests are negative.

The doctor gains much information by questioning the patient about his symptoms of pain and distress and often is influenced in his diagnosis and impression of the seriousness of the case by what the patient tells him. The doctor testifying as an expert witness who demonstrates by his testimony that he has definite knowledge of the facts and that they are the result of thorough examination will carry the most weight in court.

THE DOCTOR AS A WITNESS

By Eugene O'Dunne*

Associate Judge of the Supreme Bench of Baltimore; Lecturer on Medical Jurisprudence, Johns Hopkins Medical School; Lecturer on Criminal Law, University of Baltimore, Maryland

We are living in an age of industrial accidents in which thousands of persons are daily killed or crippled. Workmen's compensation laws, in which Maryland was the pioneer, have swept over the country and exist in some form in perhaps every state of the Union. They are founded on the principle of making industry bear the burden of its human toll.

The demand for rapid transit is met by the railroads, electric surface cars and subways, the automobile and the airplane. More persons are killed by automobiles than in the world's wars. Nearly every accident resulting in injury or death is the basis for some claim for compensation and if none is paid, generally results in the filing of a lawsuit.

Every lawsuit for personal injury requires medical testimony as to the proximate cause of death or injury or the nature and extent of the injuries. This has vastly multiplied the work of lawyers, increased their incomes and caused some branch of the medical profession to be engaged in almost every case.

The medical profession in all its specialized fields is thus called on by the law to make its contribution to the cause of justice.

Courts are merely the tribunals of organized society for the dispensation of justice according to the law of the land. The medical man as well as the lawyer should always have a clear concept of this fundamental fact, and neither should allow his zeal to close his eyes to this basic truth. It calls for the same degree of honesty which should obtain in the daily transactions of commercial life—but it is a reproach to commerce, to the legal and to the medical profession when the system in its operation falls short of honesty and fair dealing.

* Reprinted with permission from The Medical Clinics of North America March 1941—Baltimore Number. W. B. Saunders Company, Philadelphia and London.

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"There is however no higher duty upon the part of the upright lawyer and the straightforward physician than that each should protect the honor and integrity of the profession to which he belongs"

Examinations and Reports

Thoroughness is the watchword and test of sincerity in preparing full information pertaining to a case of personal injury Lawsuits are frequent in such cases and it is fully within the field of medical practice to obtain accurate information about the facts such as would throw light upon the responsibility for the injury Inquiry should be made for the names of persons and about circumstances regarding the accident to make clear the details locations, magnitude of forces that caused the accident and other facts relative to the manner of occurrence Details of observation are important The size location shape, direction and all other appearances should be investigated fully and recorded accurately Failure to make a record of a very trivial circumstance or the appearance of a wound may later be the deciding factor in a legal controversy

All physical defects other than those caused by the present injury should be observed, examined and recorded Inquiry should be made into the past history relative to previous accidents and disabilities Otherwise some previous injury may be brought in as evidence of present injury or some future development may be the result of a past injury and yet claim made that it developed from the present injury

before trial. The case may require close scientific reading of the latest medical literature. He must be prepared to stand cross-examination by rough and ready trial lawyers.

Create an Impression of Honesty

The medical man on the witness stand not only must be honest in fact but must impress the jury that he is honest, that he is desirous of being helpful in the matters of science about which he is asked, that he is impartial in the contribution of his information, and that he is not trying at all hazards to support the contention of the side which may have called him. This should be done in a polite manner, in a form as simple as the subject permits, in a tone audible, not requiring repetition, and in language capable of being understood by men of average intelligence and without technical training. Always his answers must reflect the truth.

Translate Medical Terms for Laymen

The value of a teacher in any school depends on his ability to impart his information to the class before him. He must be on a level with them. Here nearly all medical men fail hopelessly in the courts. Their minds are full of medical jargon. They know only medical terminology. They may correctly express their thought but it might as well not be expressed. The jury has no idea of what they are talking about. Unless the doctor can help direct them to the right destination he is hindering justice, rather than helping it. Simplicity is an element of greatness.

Politeness and Diplomacy

Should the Sheriff leave a summons at the doctor's office or home some evening when he is scheduled for an important operation at the hospital in the morning, then by the use of a little politeness and diplomacy he generally can call the lawyer, or if necessary the judge, and make arrangements for having his testimony taken at an hour not to conflict with the operation and still be in time for its use at the trial.

Compensation for Expert Testimony

In some states expert testimony can be forced from medical men the same as from ordinary witnesses and without compensation. In other jurisdictions the result of special study and long training is regarded much the same as private property, not to be taken without due compensation.

Where this rule prevails a medical man on the witness stand may decline to answer a question calling for expert testimony on the ground that no financial arrangement has been made to compensate him for that kind of information. He may waive his right and consent to answer expert questions without compensation, if he cares to do so.

The Legal Summons

Medical expert or general practitioner, when summoned to court, must obey. It is equivalent to the command of a king, whatever the form of government may be. It has the sanction of sovereignty behind it. It is organized society calling on the individual in the name of the law, much as in the military draft. Any excuse the doctor may have, he may present after appearing there, but not by remote control from the operating room or elsewhere. One is ordered there at the time and place specified, and must attend, or be in contempt of court and liable to a fine or imprisonment for failure to do so. Lack of this knowledge has cost some doctors substantial money, loss of reputation, loss of temper and loss of dignity, and afforded much amusement to jurors and spectators.

The Jury System

The tribunal established by society is the judicial branch of government, for the redress of personal wrongs and the protection of human rights is the court, and an agency of the courts is the jury system. It has been condemned and praised, perhaps beyond its desserts, has been wisely used and grossly abused.

The jury has long been part of the judicial machinery, and not even advanced thought has suggested its complete abolition. There is increased demand in labor circles for its further extension and much outcry against attempts at its restriction. It is well to understand something of what it is, because it is to a jury of 'his peers' that the medical man must talk in his attempt to contribute the learning of his profession to the cause of justice.

The Jury Personnel

A jury is composed of twelve honest persons selected to apply justice according to the law of the land. They need not be wiser than the twelve apostles, and some of them may be fishermen. Theroetically they are subject to the draft law as the triers of fact, as men of common experience, citizens, white or colored, male or female—a cross section of the community. Local laws generally regulate their ages. In Maryland, the age requirement is twenty-five to seventy, with many provision as to exemptions from jury duty based on a theory of public convenience for such persons as school teachers, federal and state employees, election officials, the deaf and the blind, but not necessarily the dumb.

In some enlightened states women serve on juries.

Remember always that one can expect to have a jury of only average intelligence. Some jurors even now may not be able to read or write, and their understanding of the English language may be extremely limited.

Preparing to Testify

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COMPENSATION FOR INDUSTRIAL INJURIES AND OCCUPATIONAL DISEASES SOME LEGAL AND MEDICO-LEGAL ASPECTS

By E RANSOM KOONTZ, M D , St Petersburg, Florida

Medical testimony in compensation cases all too frequently is unreliable because of the medical witness himself It is a trying task for a medical witness to be absolutely unbiased and candid To begin with, he is usually called to testify because his opinion is known to be favorable to the party calling him If the medical witness was employed by the injured or diseased workman to treat him he must be a man of great integrity to overcome the temptation to testify in such a manner as to help out the workman especially since there may be financial gain to him if disability is prolonged All too frequently, not only workmen and lawyers but also physicians attribute real or assumed pathological conditions to trauma simply because such conditions appeared after an accident Indeed it requires a physician of stern conscience and rigid integrity to resist all these various influences and testify to "the truth and nothing but the truth "

Untrustworthy medical testimony in compensation cases, which is due to the incompetence or fault of the medical witness himself, may be due to the physician who because of ignorance or lack of proper preparation, makes an honest error, the physician who dishonestly makes a guess instead of frankly confessing his lack of medical knowledge, and the physician, perhaps biased by his employment but more frequently a so-called professional expert medical witness who makes his living by deliberately giving false expert medical testimony testifies falsely Lawyers and judges use the professional expert witness only when they have to but they do not respect him His position while perhaps lucrative is certainly an unsavory one His conduct has brought discredit to the medical profession and has *done much to make honest physicians shun the courts*

THE COMPENSATION ASPECTS OF LOW-BACK CONDITIONS*

By HOWARD I PRINCE, M D , Rochester N Y

'The present status of back problems as far as the insurance companies are concerned is not flattering to the medical profession They are bewildered by the multiplicity of ideas held by us about back conditions The situation may be summed up in a quotation from a letter from the surgical head of one of the largest insurance companies ' It does seem as though in the treatment of injured backs we are no nearer a solution than we were a number of years ago The head of another large company says ' I am free to admit that we are often undecided as to the proper course to pursue in back cases As a matter of fact in 75 per cent of these cases we compromise without resorting to any operative procedure and settle for a

* Reprinted from the J Bone & Jt Surg 19 3 pp 80 809 July 1937 with changes by Dr Lewin with approval of the author

Contingent Compensation Improper —No medical expert should have his compensation dependent on the result of the case This is known as a "contingent fee," dependent on success of the litigant Such an arrangement has a tendency to warp the judgment of the witness, who has a personal and pecuniary interest in the verdict It lays him open to the impeachment of his integrity, oftentimes justly so

Compensation for expert testimony is a legitimate source of revenue to the medical expert Care must be taken not to allow employment to bias one's judgment Medical men have brought much odium on their profession by practically selling themselves to the side which employs them Sometimes their bias is conscientious, but that they are biased, is all too apparent

The "battle of the experts" is no uncommon sight in courts where the fight is for large stakes

X RAYS OF THE VERTEBRÆ*

By A W George, M D , and R D Leonard, M D , Boston, Mass

The roentgenologist is in greater demand in tort cases than any medical specialist Many of the contested medico legal cases involve testimony in regard to the spine

Certain essential features must be observed in giving expert testimony In the first place, one must qualify as an expert

An axiom of expert testimony is Be honest Another factor is the proper appearance of the witness A witness who sits or stands upright in the witness box and answers the questions definitely and precisely, directing his replies to the jury, will make a far better impression than one who assumes a careless position and is not precise in his replies After all, the value of one's testimony is judged solely by a body of twelve men selected from different walks of life By his appearance and manner in which the witness answers the questions, the impression should be conveyed that he knows his subject matter, has nothing to conceal and is absolutely honest in his opinion

Oftentimes the witness will find himself in a difficult position in an attempt to be honest in his testimony He should bear in mind the fact that he is in the witness box to answer questions

If a hypothetical question is asked which cannot be answered by yes or no, the witness should state and insist on the privilege that he is unable to answer in such a manner He has the court the judge, behind him

As a rule lawyers are not familiar with medical subject matter yet some experienced tort lawyers are superficially familiar with ordinary medical conditions Again some lawyers are expert enough to study up the matter prior to the case If the opposing counsel is keen and those for the defense usually are he may entangle the witness and lead him into subjects with which he is not familiar Immediately the witness is disqualified as an expert in the eyes of the jury

* Ann Roent vol. 8 pp 243-249 1932

dition The surgical treatment proposed is stabilization of the sacro-iliac joint On the same case another surgeon makes a diagnosis of a ruptured intervertebral disk and the treatment suggested is an operation on the disk We have cases where such a diagnosis was made and operations were performed by some of the finest neurological surgeons in the country, and the condition diagnosed, was not found In one of these cases a stabilization operation on the lumbosacral joint was performed in 1934 and the man is still disabled In another instance in one of the large clinics of the country, diagnosis of a lumbosacral condition was made and lumbosacral stabilization was performed Symptoms persisted after the operation, diagnosis of a ruptured intervertebral disk was then made Operation was performed and such a condition found In another case, two outstanding orthopedic surgeons examined a man, one suggested a stabilization operation for the sacro-iliac joint, the other advised an operation for a ruptured intervertebral disk

Recently I have had opportunity to study the end-results in a fairly sizable group of cases recorded by one insurance company The operations were performed by experienced surgeons It is this sort of experience which leads to the following quotation "Following an observation of fifteen years in the diagnosis and treatment of low-back conditions, it is our opinion that, with a few exceptions, conservative treatment has shown better results than operative treatment" Why should this be? Either our knowledge of anatomy is faulty our interpretation of its indications is wrong, or we have taken the intangibles, mentioned earlier, into too little consideration

The question of injury to a disk with extrusion of part of it, into the spinal canal is important, but there are serious questions to be answered before the rank and file of surgeons adopt it

There is little advantage to the claimant or to the insurance company if a brilliant operation is done and the claimant is no more able to do active work than he was before

Surely certain members of the profession because they are selecting their cases with great care after a careful diagnosis, and because they are skillful operators, can solve some of these back problems satisfactorily

Much of the responsibility for the after-results falls on the first medical man who sees the injured back All of these backs in my opinion should be rested Frightening the patient or fixing in his mind the idea that he has a serious back injury should be avoided Strapping the back and a few days rest on a hard bed with the application of a little local heat—perhaps relaxing the patient completely with morphine for the first forty-eight hours—will enable the patient to get back to work when he feels that he can He has a feeling of having been well cared for, and his inclination is *to return to work* The psychological character of the patient, as well as his physical condition should be taken into consideration in every case

When the question of the need or the advantage of operation for low-back conditions is paramount we should deliberate most carefully, because if we give certain types of persons a scar, they will never get out of the compensation class"

lump sum " Again quoting "One of the greatest difficulties with which we have to deal is to obtain a correct diagnosis In a number of instances these industrial cases are examined and reported upon by outstanding *specialists and we are confronted with reports in regard to the conditions* found and treatment proposed, often surgical, completely at variance, one with the other " Quoting from another company "A great many methods of treatment have been used in compensation cases, none of which, apparently, so far as relief is concerned, has accomplished its purpose One method of treatment is just as good as another—it would appear that there is no choice "

I believe that the crux of the difficulty lies in the fact that every case presents a combination of a psychological and an anatomical factor Not until both factors are given due and proper consideration are we going to achieve much better results than we have to date

The compensation case is often influenced by personal traits which we cannot change and about the handling of which we know little, by marital conditions and, particularly, by economic conditions Think of the strain *on an injured man s ethics during the past several years, when to get well* meant to give up compensation and become jobless

Doctors talk about "traumatic neuroses" in these cases For example, Doe stoops to lift a box and gets a catch in his back For weeks, months or years he is afflicted by steady pain—severe enough to prevent working but not bad enough to keep him from gaining weight and looking hale and hearty while he draws fifteen or twenty dollars a week Quiverings and twitchings and a woebegone look gradually develop when he is at court hearings Dumb as he is he learns that on examination certain activities on the part of the examiner, call for certain responses on his part He can always find a doctor who will agree that, while objective symptoms are lacking it is curious that so slight an injury should cause so long a period of disability and he is unable to return to work He has a "traumatic neurosis If the possible effect of the fifteen or twenty dollars per week is brought up as a factor in this neurosis, it is brushed aside as being of no moment—it is probably just a capitalistic myth

Compensation laws are rightly designed to protect the claimant He should have the benefit of the doubt but his advantage may become too great when a lay commissioner has the final decision, as to whether the claimant is disabled

If employers could and would help us in handling these cases, some gain would be made Small employers often cannot and large employers often will not take these men back for light work—that is, work requiring little strain on the back—for a period of several weeks and then let them gradually get hardened again In many cases this would be a helpful procedure

The development of our present knowledge of the low back is interesting Great advances in diagnosis and treatment have been made Much has been contributed to the anatomical knowledge of the lower part of the back With the development of these ideas emphasis has been placed on surgical measures as well as on various other methods

Still the insurance companies are in trouble as shown by the following quotation 'For instance we may have a diagnosis of a sacro iliac con

examination of which it is a part. The roentgenogram does not print the diagnosis nor write the prescription for treatment. It is not a measure of disability. It is impossible in a large number of cases to obtain results which are perfect from the roentgen standpoint, even with the best treatment at the hands of the most expert. It is a mistake to show roentgenograms to patients, friends or relatives. The patient who protests that he is unable to afford a roentgenogram is just the one who will cause legal trouble if he possibly can.

ESTIMATION OF DISABILITY OF THE BACK

Back disability means the inability of the back to perform the ordinary acts or movements under circumstances usually considered to be normal. Disability is defined as the inability of a workman to carry on his usual work temporarily, permanently, totally, or partially. There are several kinds of disability: temporary-total, temporary-partial, permanent-total, permanent-partial, and a cosmetic defect.

The causes of disability are direct, predisposing and pre-existing. The causes of back disability are muscle weakness, pain, fatigue, contractures, deformities, muscle imbalance, habitual incorrect posture and unprotected premature functional use. In the movement of the back the two most important factors are the muscle power and the range of movement. Disability may be manifested by weakness of part or all of the back in performing its physiological functions under normal conditions. The treatment includes mechanical apparatus, physical therapy, psychological adjustment and surgical procedures. Prevention is the watchword. Injuries should be guarded against but when they have occurred, their effects must be minimized by immediate appropriate treatment. Prolonged immobilization increases the period of temporary total disability and often leaves permanent partial disability. It is important to start the injured person on light work as soon as possible.

The factors entering into the treatment of vertebral fractures in industry are: (1) the duration of the disability, (2) the financial loss to the employee, (3) the financial and productive loss to the employer, (4) the sacrifices made by the employee's family, (5) the mental reaction and cooperation of the employee, (6) the cooperation of the employer, and (7) the end-result. Financial loss to the employee often forces him to resume work too early. Criteria of the results are: the residual disability and deformity, and the time required to secure the end-result.

Universal workmen's compensation legislation has placed the ultimate cost of fractures of the spine squarely on industry. It has been estimated that spinal injuries cost railroads of the United States approximately $50,000,000 annually, and that $25,000,000 of that amount represents waste due to ineffective treatment.

Medico-legal Aspects of Fractures of the Vertebræ.—According to Sherman, 66 per cent of malpractice suits are based on unsatisfactory *functional* end results following fractures. In an article on damages to bones and reputation, Hey Groves says that in 90 per cent of all cases in which litiga-

OWNERSHIP OF ROENTGENOGRAMS

By S. W. DONALDSON, M.D., Ann Arbor, Michigan

The modern radiologist is a medical consultant. He is a graduate of a medical school and has spent several years in postgraduate training in order to be properly qualified to interpret rotentgenograms and administer radiation therapy.

The patient frequently asks for the roentgenograms. Some patients wish to keep them as souvenirs, others feel they are entitled to them because a specific fee has been paid the radiologist, and still others want to use them in "shopping" from one physician or surgeon to another until they secure an opinion that they are willing to accept. Roentgenograms constitute a permanent record that should be available for comparison in the event of subsequent examination.

The patient pays for opinion and diagnosis and not for the radiograms. In 1913, Skinner said: "The patient and the medical attendant are entitled to the radiologist's opinion but never to the plates."

A committee representing the members of the American Roentgen Ray Society assumed the attitude that no report should be given to the patient except through the referring physician or surgeon. Patients are sent for consultation and diagnosis and are not entitled to plates or prints. Prints in the hands of patients lead to false interpretation, confusing opinions, multiplicity of advice and bad results.

The Radiological Society of North America adopted a resolution which reads, "... it is the sense and judgment of the Society, that all roentgenograms, plates, films, negatives, photographs, tracing and other records of examination are hereby declared to be the exclusive property of the radiologist who made them or the laboratory where they were made."

Although the roentgenograms are the legal property of the radiologist, the patient still has a legal interest in them. The radiologist who acts in the capacity of a consultant cannot divulge information to any one but the referring physician or other consultants.

The New York Industrial Commissioner has ruled that roentgenograms relating to compensation cases shall be kept on file by all physicians, hospitals, roentgen ray laboratories, insurance carriers and employers for at least five years. "No x-ray plates shall be destroyed which may be involved in any open or active compensation case." The question whether the roentgenograms of a hospital patient belong to the patient or to the hospital was answered by a court which decided that the hospital sold and patients paid for, not the material that went into roentgenograms, but knowledge and experience. Roentgenograms made for a physician to assist in diagnosis and treatment are a part of the records of the case.

It is recommended that every radiologist accede to the opinion that the roentgenograms are the property of the radiologist. A wave of malpractice suits and unfavorable and unjust criticism of results has been based largely on roentgenograms.

The roentgenogram does not make a clinical diagnosis and should not be accepted as such. It should only be used in conjunction with a clinical

examination of which it is a part. The roentgenogram does not print the diagnosis nor write the prescription for treatment. It is not a measure of disability. It is impossible in a large number of cases to obtain results which are perfect from the roentgen standpoint, even with the best treatment at the hands of the most expert. It is a mistake to show roentgenograms to patients, friends or relatives. The patient who protests that he is unable to afford a roentgenogram is just the one who will cause legal trouble if he possibly can.

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tion resulted from the treatment of fractures, the main point on which a charge of negligence was based was the lack of roentgenograms

Referees and industrial commissioners, according to M O Henry, want estimates of the loss of function expressed in concrete terms They require that the relation between the injured part and the entire part be expressed in terms of percentages They expect the estimate to be a guess but there is no reason why it should be one The law does not demand that the rating be done according to any particular system or the teaching of any particular authority A fair rating is based upon a careful history, thorough examination, reliable records, and a well-grounded knowledge of the subject, to which Henry adds, "competent consultation"

Table 10 —Permanent Disability Following Injuries of the Back

(Examples of approximate evaluations where percentage of loss is determined at the end of the healing period and competency to return to work) Functions affecting disability reaching balancing lifting pulling pushing throwing striking carrying running jumping stooping 100 per cent loss = total body incapacity to work
(Courtesy of McBride and Lippincott Co)

	Quickness speed alertness	*Coordination correlation arms legs body*	*Strength power leverage*	*Security reliability confidence control*	*Endurance stability toleration*	*Safety as a workman*	*Prestige of physique Chance of employment*	*Total value of body*
	Value	*Value*	*Value*	*Value*	*Value*	*Value*	*Value*	
Clinical factors contributing to disability	10%	20%	0%	10%	20%	10%	10%	100%
	Delayed action Loss	Awkwardness Loss	Weakness Loss	Insecurity Loss	Fatigue Loss	Increased risk Loss	Adverse influence Loss	*Per cent loss to body (sum of factor losses)*

The aggravation of existing diseases may easily involve every phase of medicine Considerable responsibility is thus thrust upon the surgeon rating disability, he must be fair to both sides, and at the same time uphold his own integrity and the honor of his respected profession He must always bear *in mind the interests of the employee, the employer* and the community in general The ability of a permanently disabled workman to rehabilitate himself and to adapt himself to a changed environment varies with his age and occupation Not only will it be more difficult for an older man to learn a new trade, but his age will be a bar to re-employment Several authorities have advocated education of the general population, industrial workers, insurance companies and industrial boards to the necessity of making roentgen ray examinations before the prospective employee is employed

Disability evaluation *is a subject that requires special knowledge and* training McBride devised a process of arriving at a reasonable and trustworthy opinion in the rating of physical disabilities

There is no schedule that can adequately define and classify all the variations of physical disability Each case must receive individual consideration Disability is based on function

There are a great many factors which make it impossible to determine accurately, the extent of disability based solely on the physiologic or economic loss These factors are as follows

1 Rehabilitation obstacles
2 Limited occupational opportunities
3 Economic handicaps
4 Limited educational background
5 Adverse social relations
6 Unfavorable labor situations
7 Adverse incentive toward work
8 Age limitations
9 Unpredictable exacerbations of pain or other symptoms
10 Other body impairment or disease

The measuring rod of function may be applied to determine the ability to work at a single specified occupation, or it may apply to work in general

Estimation of Percentage of Disability Following Back Injuries

One of the most vexing problems presented by the various compensation laws, according to McBride, is the estimation of percentage of disability when permanent, irreparable damage has been done to a patient by industrial injury The final percentage of disability allowed is in the commissioners hands The value of standard criteria whereby physicians can be uniform in their opinions concerning the percentage of disability resulting from a given type of deformity or loss of function is self-evident Practi-

McBRIDE'S CRITERIA OF DISABILITY EVALUATION*

EXPRESSED IN PERCENTAGE ARE	
Quickness	10
Coordination	20
Strength	20
Endurance	20
Security	10
Risk	10
Subsequent Employment	10
	100

* McBride E D —Disability Evaluation 3d Ed Philadelphia J B Lippincott Company 1942 p 494

cally all tables of percentage of disability have been prepared by laymen

Temporary total disability is the period of incapacity during the healing period The permanent disability schedule of loss represents the probable average loss of earning capacity resulting from the effect of the permanent disability It should not therefore include the healing period Compensation for permanent partial disabilities should be expressed, not in a specified number of weeks compensation, but in percentages of permanent total disability

Estimation of percentage of disabilities in injuries of the back is extremely important The correct solution of the problem can be arrived at only by the frank cooperation and discussion of the industrial surgeon, the orthopedic surgeon and the Industrial Commission Justice must be done to the injured person the insurance company and the surgeon

Numerous attempts have been made to solve this problem by individuals, insurance companies and compensation boards and surgeons

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(Examples of approximate evaluations where percentage of loss is determined at the end of the healing period and competency to return to work) Functions affecting disability reaching balancing lifting pulling pushing throwing striking carrying running jumping stooping 100 per cent loss = total body incapacity to work
(Courtesy of McBride and Lippincott Co)

	Quickness speed alertness		*Coordination correlation arms legs body*		*Strength power leverage*		*Security reliability confidence control*		*Endurance stability toleration*		*Safety as a workman*		*Prestige of physique Chance of employment*		*Total value of body*
	Value		*Value*		*Value*		*Value*		*Value*		*Value*		*Value*		
Clinical factors contributing to disability	10%		20%		20%		10%		20%		10%		10%		100%
	Delayed action	Loss	Awkwardness	Loss	Weakness	Loss	Insecurity	Loss	Fatigue	Loss	Increased risk	Loss	Adverse influence	Loss	*Per cent loss to body (sum of factor losses)*

The aggravation of existing diseases may easily involve every phase of medicine Considerable responsibility is thus thrust upon the surgeon rating disability, he must be fair to both sides, and at the same time uphold his own integrity and the honor of his respected profession He must always bear in mind the interests of the employee the employer and the community in general The ability of a permanently disabled workman to rehabilitate himself and to adapt himself to a changed environment varies with his age and occupation Not only will it be more difficult for an older man to learn a new trade, but his age will be a bar to re-employment Several authorities have advocated education of the general population, industrial workers, insurance companies, and industrial boards to the necessity of making roentgen ray examinations before the prospective employee is employed

Disability evaluation is a subject that requires special knowledge and training McBride devised a process of arriving at a reasonable and trustworthy opinion in the rating of physical disabilities

There is no schedule that can adequately define and classify all the variations of physical disability Each case must receive individual consideration Disability is based on function

There are a great many factors which make it impossible to determine, accurately, the extent of disability based solely on the physiologic or economic loss These factors are as follows

1 Rehabilitation obstacles
2 Limited occupational opportunities
3 Economic handicaps
4 Limited educational background
5 Adverse social relations
6 Unfavorable labor situations
7 Adverse incentive toward work
8 Age limitations
9 Unpredictable exacerbations of pain or other symptoms
10 Other body impairment or disease

The measuring rod of function may be applied to determine the ability to work at a single specified occupation, or it may apply to work in general

Estimation of Percentage of Disability Following Back Injuries

One of the most vexing problems presented by the various compensation laws, according to McBride, is the estimation of percentage of disability when permanent, irreparable damage has been done to a patient by industrial injury The final percentage of disability allowed is in the commissioners hands The value of standard criteria whereby physicians can be uniform in their opinions concerning the percentage of disability resulting from a given type of deformity or loss of function is self-evident Practically all tables of percentage of disability have been prepared by laymen

McBRIDE'S CRITERIA OF DISABILITY EVALUATION*

EXPRESSED IN PERCENTAGE ARE	
Quickness	10
Coordination	20
Strength	20
Endurance	20
Security	10
Risk	10
Subsequent Employment	10
	100

* McBride E D —Disability Evaluation 3d Ed Philadelphia J B Lippincott Company 1942 p 434

Temporary total disability is the period of incapacity during the healing period The permanent disability schedule of loss represents the probable average loss of earning capacity resulting from the effect of the permanent disability It should not therefore include the healing period Compensation for permanent partial disabilities should be expressed not in a specified number of weeks compensation but in percentages of permanent total disability

Estimation of percentage of disabilities in injuries of the back is extremely important The correct solution of the problem can be arrived at only by the frank cooperation and discussion of the industrial surgeon the orthopedic surgeon and the Industrial Commission Justice must be done to the injured person the insurance company and the surgeon

Numerous attempts have been made to solve this *problem* by individuals insurance companies and compensation boards and surgeons

The reader is referred to books and articles by Kessler, McBride, Brahdy and Kahn, Johnstone, Henry and Evans, and Jordan McBride has reduced the subject to a mathematical formula

Non Traumatic Disability

A frequent and troublesome complication of the industrial back emphasized by McBride is the psychological attitude of exaggeration developed in the patient by the fact that litigation is in progress or contemplated The subjective symptoms are magnified and objective signs are difficult to find When the symptoms are chronic but related to the history of an accident, McBride considers that the alleged accident was a coincidence and not the cause of the disabled state

Following the lead of McBride I formulated a plan for estimating disability of the back All the subjective and objective elements are variable and reciprocal as to individual values I have, therefore, for practical purposes, given each a decimal value One must consider the physiology, function and biomechanics of the back as a unit and as a part of the entire body

Estimation of Back Disability

	Components*	Unit value	% of loss of unit value	Remainder
1	PAIN	10%		
2	DEFORMITY	10%		
3	DISABILITY	10%		
4	OCCUPATION INDEX	10%		
5	REEMPLOYMENT INDEX	10%		
6	RECURRENCE INDEX	10%		
7	EFFECT ON OTHER PARTS OF THE BODY	10%		
8	PSYCHO SOMATIC EFFECT	10%		
9	BEHAVIOR CHARACTERISTICS	10%		
10	MISCELLANEOUS FACTORS	10%		
	TOTAL	100%		
	DISABILITY			

* Elaborated upon on opposite page

1 I am
- during
  - day
  - night
- during activity at
  - work
  - play

---

2 Deformity
- appearance—posture
  - primary
  - secondary
- height of person

---

3 Disability
- function
  - alertness
  - coordination
  - strength
  - endurance
    - at work
    - *at play*
    - at home

---

4 Occupation Index (previous occupation)

---

5 Reëmployment Index
- person s previous occupation
- a new occupation
- reduction of wages
- reduction of desirability

---

6 Recurrence Index
- real
- imaginary
- insurance index

---

7 Effect on Other Parts of the Body
- physical
- mental

---

8 Psycho-somatic Effect
- fear
- inferiority complex
- ecurity
- risk of future injury

---

9 Behavior Characteristics attributable to Back Disorder
- impression on other people
  - real
  - imaginary
- effect on happiness of person
  - athletics
  - amusements
- effect on his household

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10 Miscellaneous Factors
- impression on examiner

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